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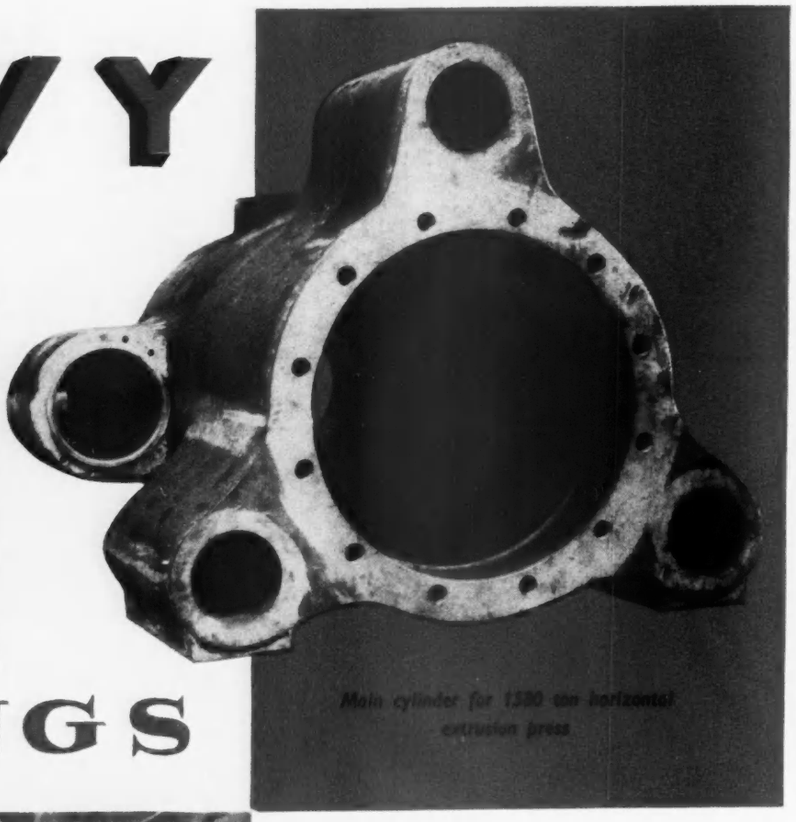
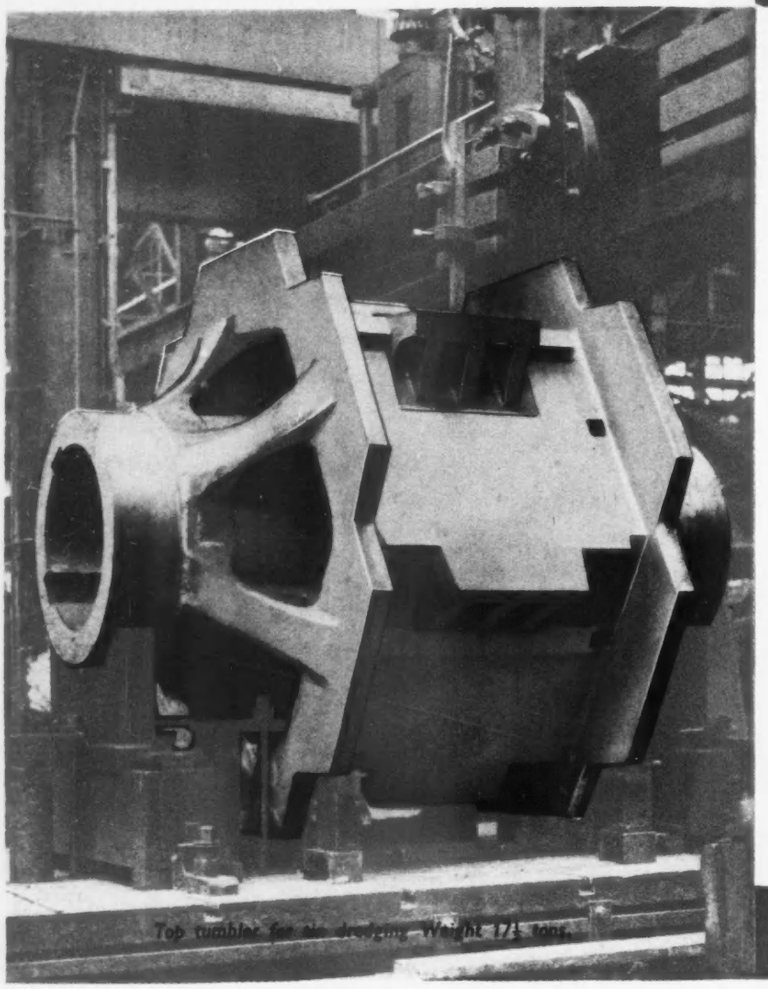


Main cylinder for 1320 ton horizontal extrusion press



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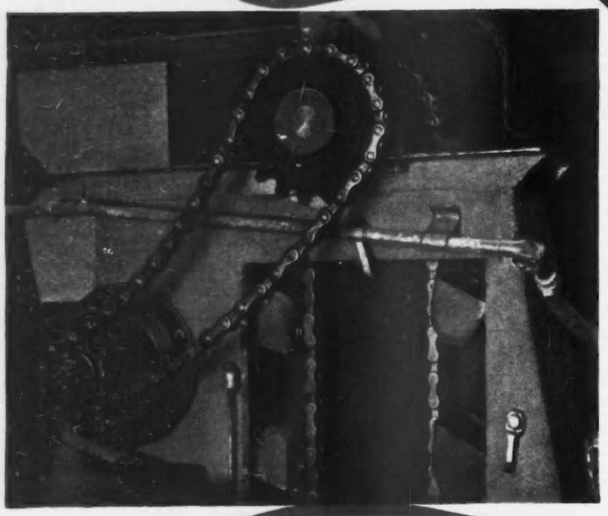

The Coventry Mark 5 chains, especially designed for slow-speed driving and light conveying in rough and exposed conditions, are rapidly replacing malleable and pressed steel chains. Manufacturers are realising that, although the initial cost of a chain with rollers is naturally higher, the goodwill created by the greatly improved performance and very much longer life of The Coventry Mark 5 chains outweighs other considerations.

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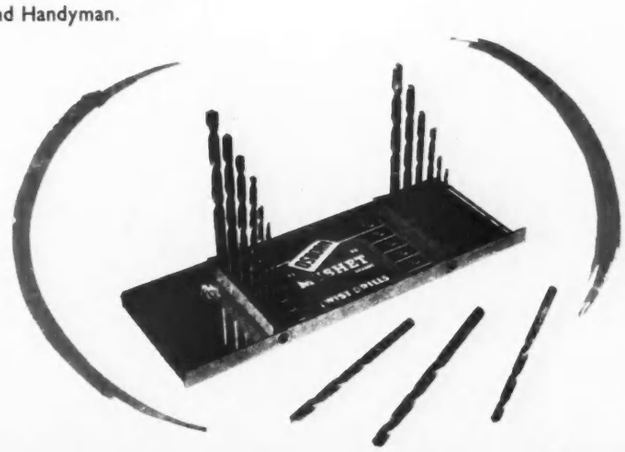

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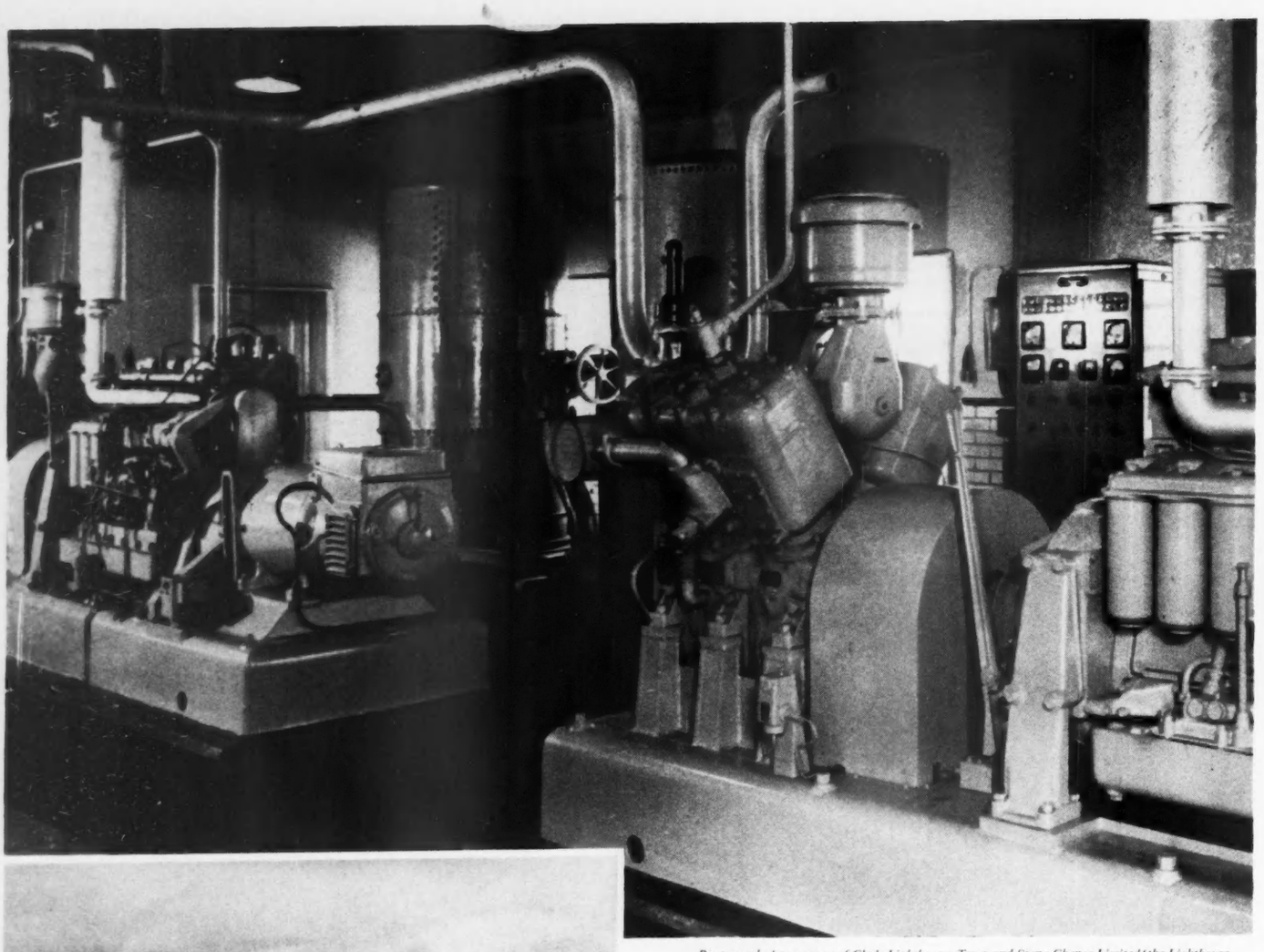

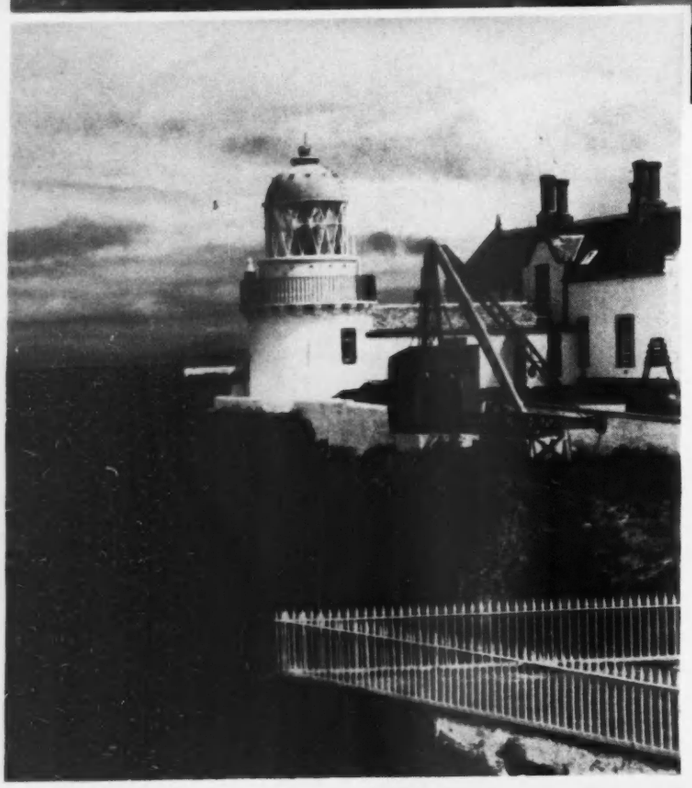

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Founded in 1866

ENGINEERING

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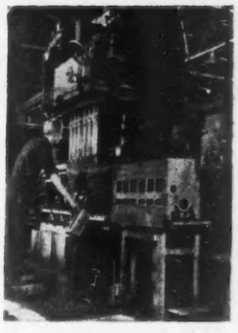

Cover Picture
Boring the liner bores of a six-cylinder crankcase in a special-purpose six-spindle vertical boring machine. It will be seen that an air-operated fixture is being used. (*Nurnberg photograph for* ENGINEERING.)

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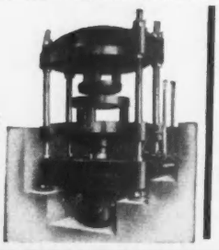

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(The diagram shows information required when ordering this type of spring.)

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The course will deal mainly with performance, systems, turbomachine aerodynamics and related design topics, but will include some experimental work on engines.

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Further details and copies of the syllabus may be obtained on application to the WARDEN, THE COLLEGE OF AERONAUTICS, CRANFIELD, BLETCHLEY, BUCKS. A 905

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"FOR THE SUPPLY OF IS NOS. GLIDER LAUNCHING WINCHES with 100 b.h.p. petrol engine to launch gliders up to 550 kg."

Specification, etc., can be obtained from the Coordination Branch, India Store Department, Bromyard Avenue, Acton, W.3, at a cost of 10 shillings per tender. The Tenders are due to be returned to India Store Department, at the above address, so as to reach them by 2 p.m. on Monday, 29th February, 1960.

Specimen copy of the above specification can be seen at ENGINEERING BRANCH, INDIA STORE DEPARTMENT, ACTON, W.3, under the following reference. 2360/59/ENG.2. B 89

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ROLLS ELECTROMATIC WASHING MACHINES

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Manufacturers of wash tubs, motors, vitreous enamelling, stove enamelling plant, tools, tool capacity, steel pressings and spinnings etc.

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5 Cotton waste, cleaning cloth, wipers, hemp tarpaulins, etc.
6 Motor tyres, tubes, batteries, oils, etc.
8 Mild steel bars, plates, sheets, etc.
9 Black bolts and nuts, screws, files, shovels, etc.
10 Lead, pipe, solder, sheet, etc.
11 Fuel oil, kerosene, motor spirit.
12 Special lubricating oils.
13 Soaps, polishes and cleansers, oilman's sundries, paper towels and toilet rolls, etc.
14 Rubber and canvas insertion sheet and washers; suction, delivery, chemical and fire hose, etc.
19 Small iron castings, valve, hydrant and stopcock boxes, etc., non-ferrous castings.
20 Stopcocks, ferrule stopcocks, unions, disc fittings, hydrant outlets and caps.
21 Sluice valves, fire hydrants and parts, extension spindles, hydrant indicator plates, etc.
23 Periodical inspection, repair and maintenance of weighing apparatus.
24 Electric lamps and fluorescent tubes.
25 Steam, smithy and house coal, and coke.
26 Removal of furnace refuse.
27 Photo prints, etc.

Tenders must be submitted on the official forms which may be obtained from the Chief Engineer by personal application at the offices of the Board (Room 171) or upon forwarding an addressed envelope (not smaller than 15 in. by 10 in.) and enclosing stamps value 1s. 0d. to cover postage, etc.

Applicants should refer to the number of the contract for which tender forms are required.

Tenders, enclosed in sealed envelopes addressed to the undersigned and endorsed in the manner indicated in the form of tender, must be delivered to the office of the Board (Room 122) not later than 12 noon on Thursday, 4th February, 1960.

The Board do not bind themselves to accept the lowest or any tender.

S. D. ASKEW, CLERK TO THE BOARD.
OFFICES OF THE BOARD,
NEW RIVER HEAD,
ROSEBERRY AVENUE, LONDON, E.C.1. B 34

THE COMMISSIONERS FOR THE PORT
OF CALCUTTA
CHIEF MECHANICAL ENGINEER'S
DEPARTMENT

INVITATION TO TENDER

TENDERS are invited from experienced firms for the construction, **SUPPLY AND DELIVERY OF ONE 250-TON CHAIN TESTING MACHINE** at the Port of Calcutta.

Tender forms and specifications may be obtained from Messrs. RENDEL, PALMER & TRITTON, CONSULTING ENGINEERS AND LONDON AGENTS TO THE COMMISSIONERS, 125, VICTORIA STREET, WESTMINSTER, LONDON, S.W.1, upon payment of £1 10s. 0d. (One Pound Ten Shillings) per copy and at the office of the Chief Mechanical Engineer to the Commissioners for the Port of Calcutta, 8, Garden Reach Road, Kidderpore, Calcutta 23, India, on production of a receipt for Rs. 20/- (Twenty Rupees) for each copy, from the Commissioners' Treasurer at 15, Strand Road, Calcutta 1, India. This amount is not refundable under any circumstances.

Tenderers before submission of tenders must deposit with Messrs. Rendel, Palmer & Tritton or the Commissioners' Treasurer an amount to the extent of 1 per cent. (One per cent.) of their tendered value as Earnest Money, which will be refunded to the unsuccessful tenderers on the award of the tender being made and in the case of the successful tenderer he shall have to deposit a further sum which, together with the Earnest Money already deposited shall equal to 10 per cent. (Ten per cent.) of the contract value and be retained as Security Money for the successful execution of the contract.

Tenders in sealed envelopes, endorsed on the outside "Tenders for 250-ton Chain Testing Machine" are to be submitted in triplicate of which two copies are to be sent to the Chief Mechanical Engineer and the remaining copy to the Consulting Engineers so as to reach them not later than 10 a.m. G.M.T. in London and 3 p.m. I.S.T. Calcutta on Thursday, the 21st April, 1960.

Tenders will be simultaneously opened at the above two premises shortly after the closing time referred to above and any tenderer who wishes to be present at the time of opening may do so.

Quotations from the Tenderers must be firm and remain open for a period of 18 weeks from the closing date of tender.

The Calcutta Port Commissioners do not bind themselves to accept the lowest or any tender and reserve the right to accept or reject any tender without assigning any reason.

S. K. MITRA,
CHIEF MECHANICAL ENGINEER. B 93

THE OFFICE OF THE CHIEF ENGINEER, MADRAS PORT TRUST, MADRAS, INDIA, invites **TENDERS** for the following:

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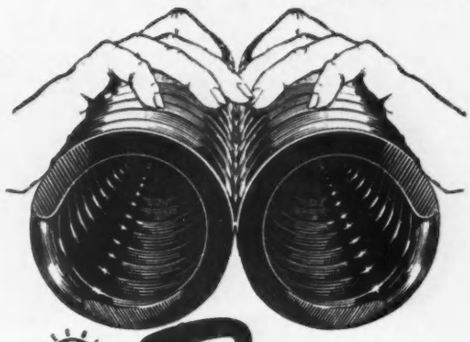

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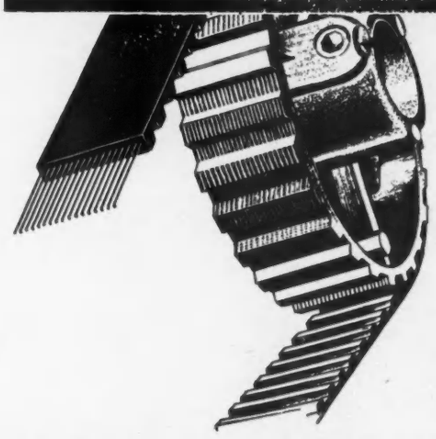

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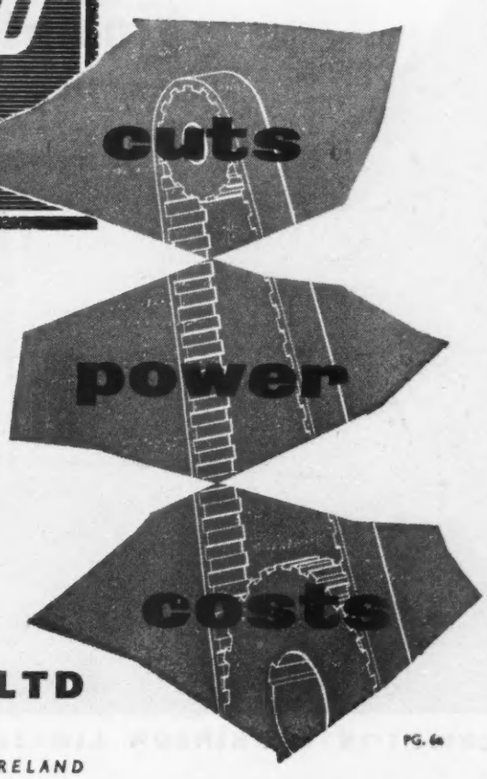

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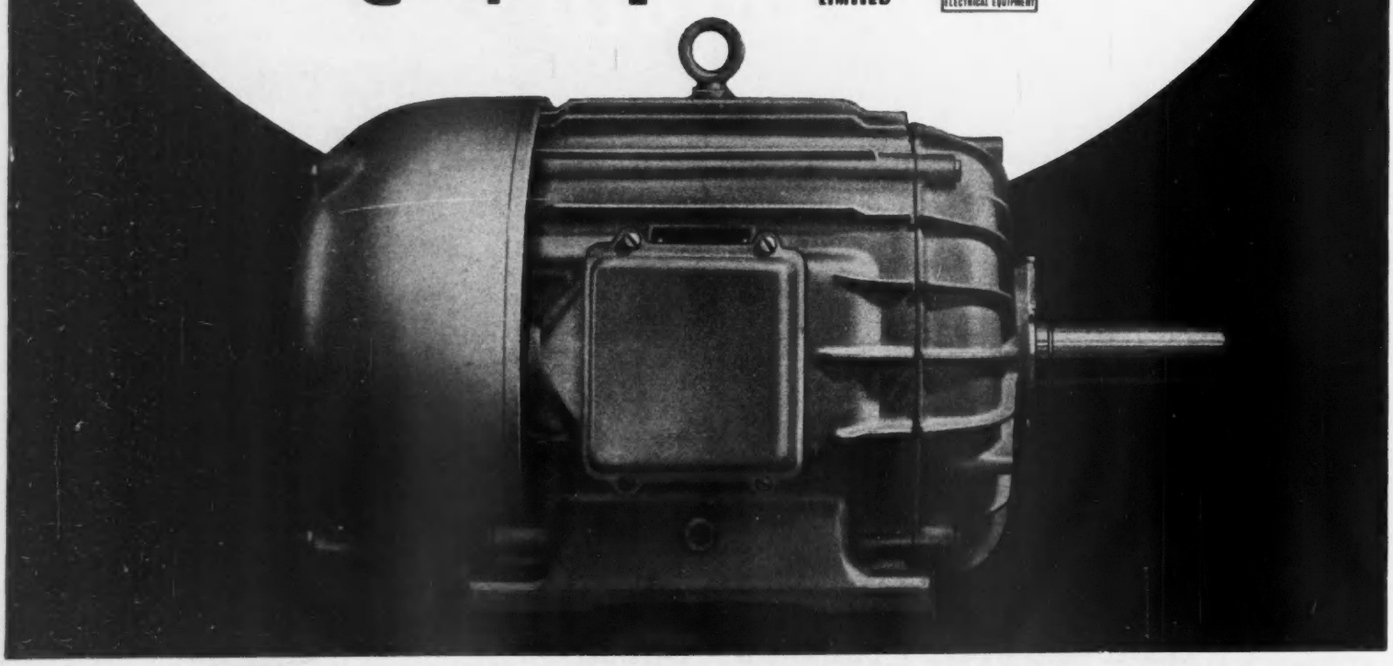

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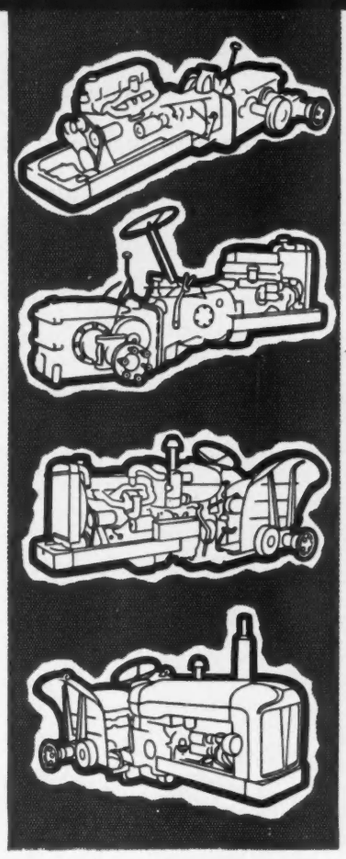

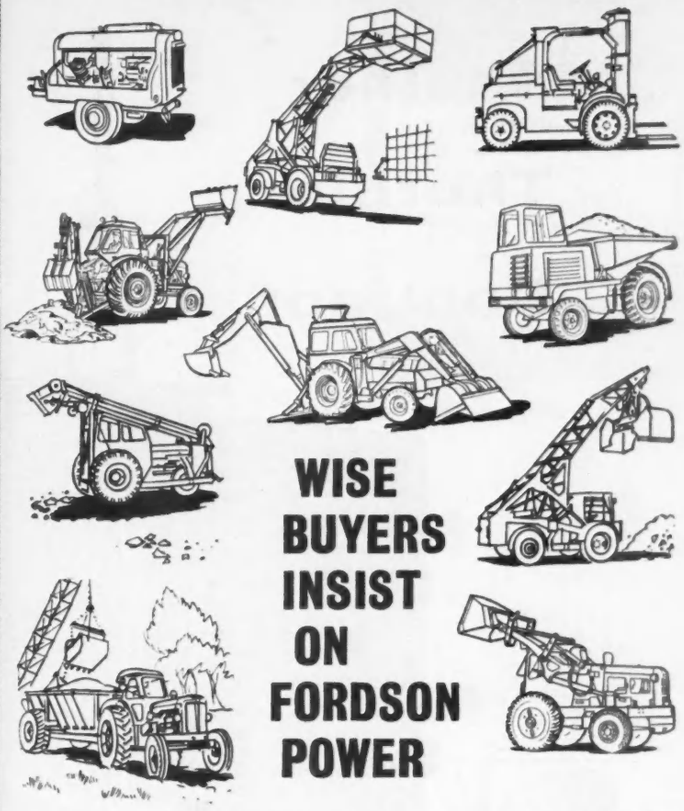

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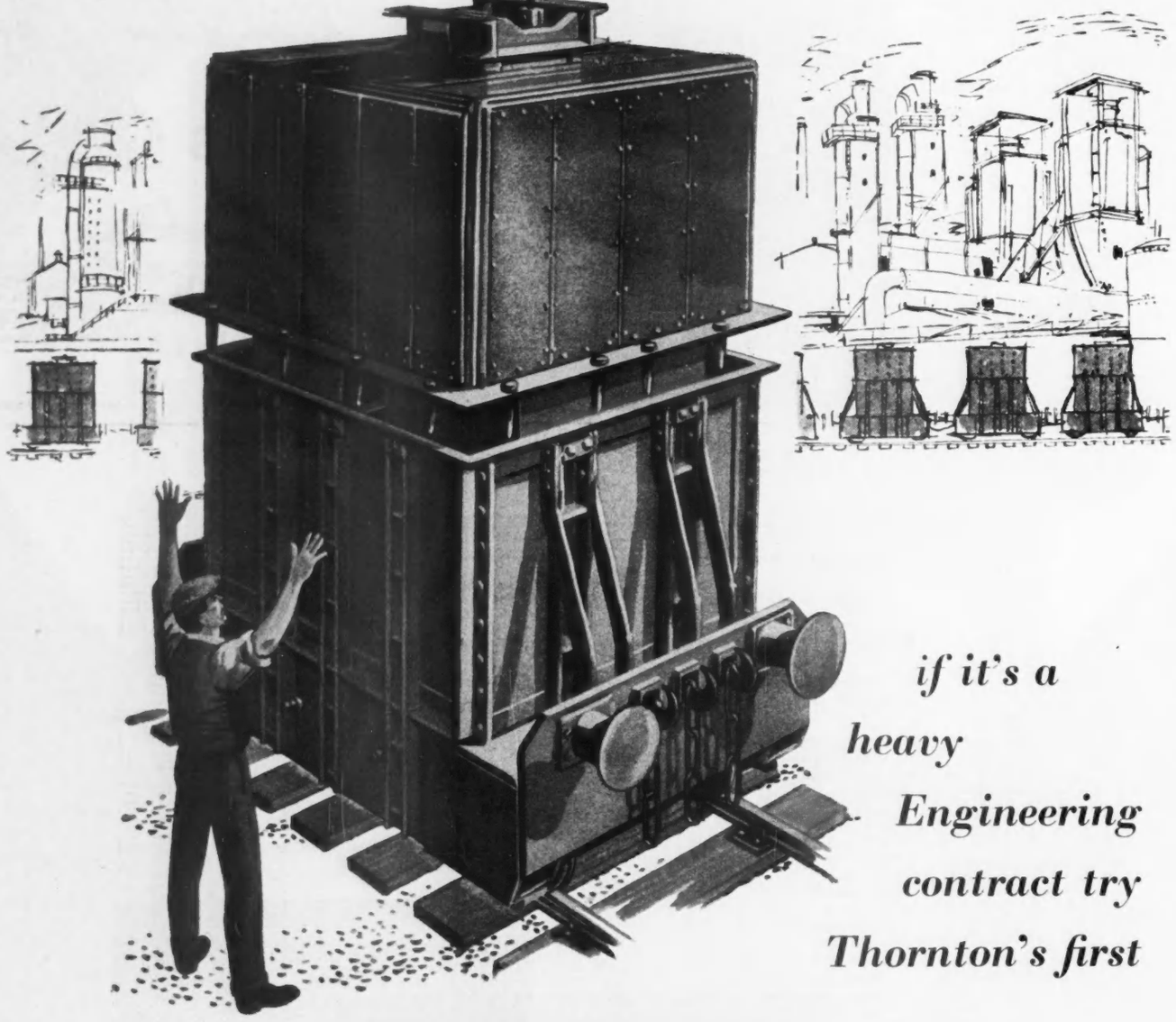

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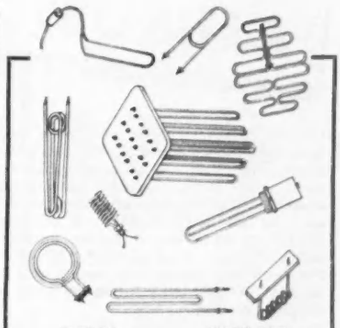

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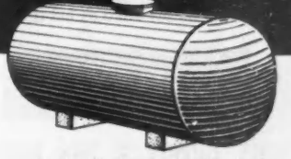

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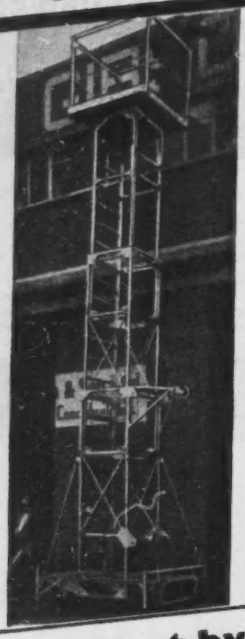

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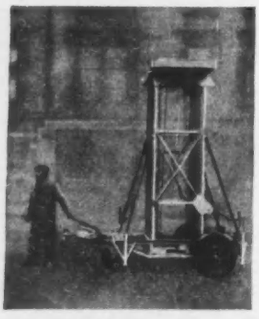

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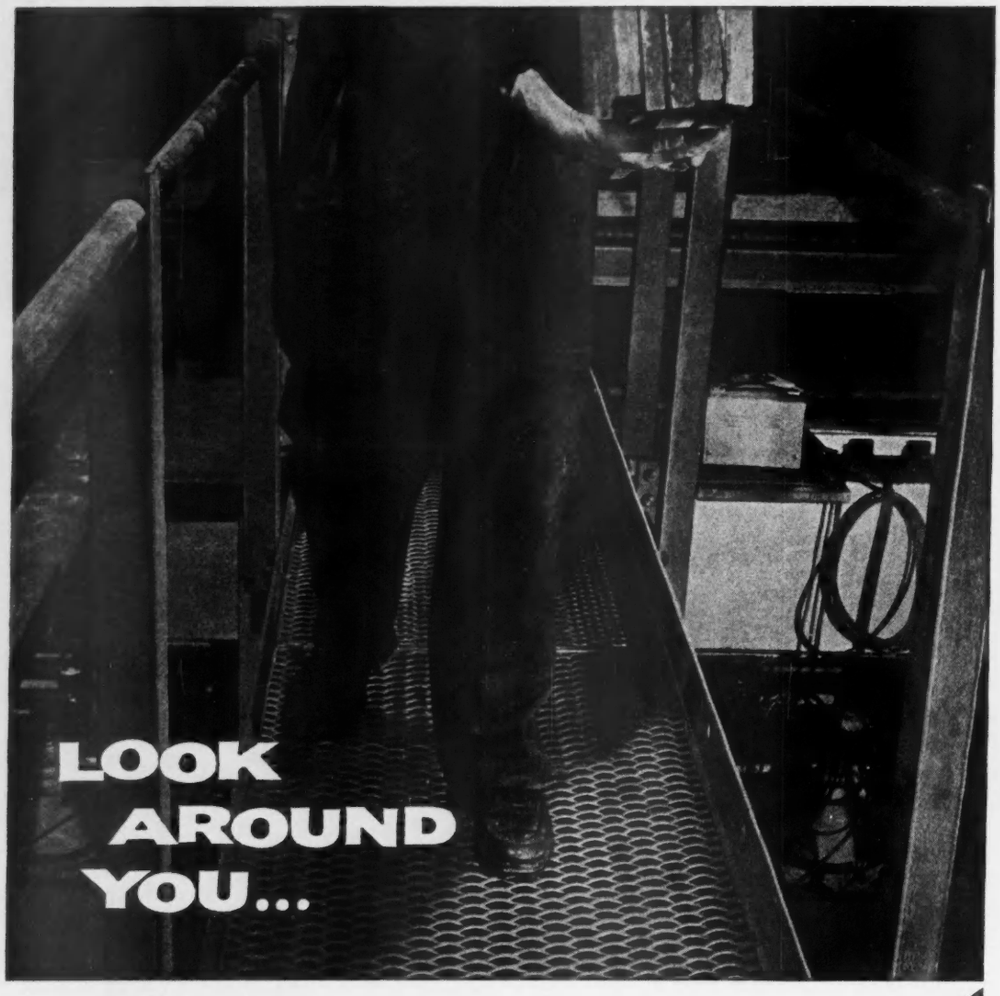

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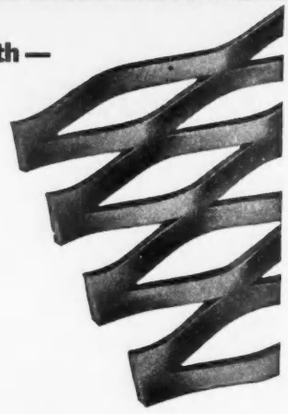

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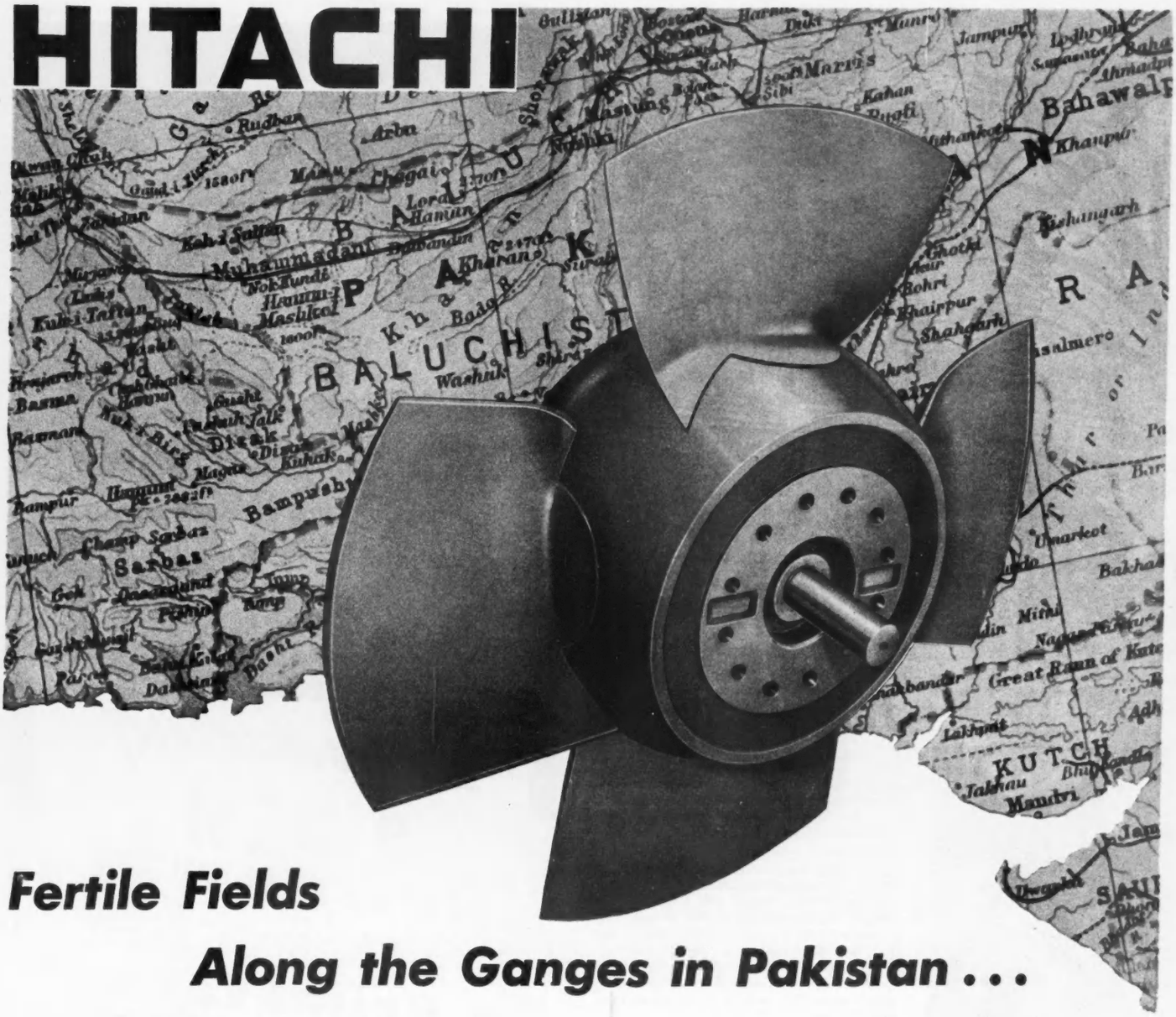

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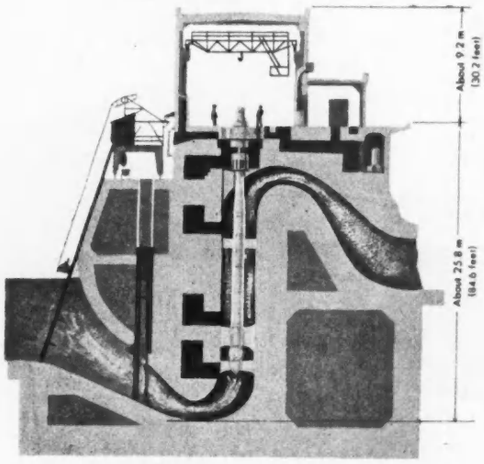


. . . will be made possible through the three (3) huge Vertical Type Adjustable Blade Axial Flow Pumps built by Hitachi for East Pakistan. Each pump has a motor output of 2,800 kW and a 2,700 mm impeller diameter. To be installed in East Pakistan for pumping water from the Ganges River during the dry season for irrigation purposes, the pump is only part of the equipment for the huge Pump Station being supplied by Hitachi, including the screen and gate on the suction side, a trash rack crane and an electric overhead crane.

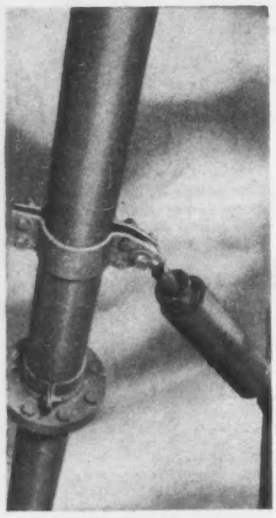
Outline of this Pumping Plant

Type-Form	Vertical Shaft Direct Motor Driven Adjustable Blade Axial Flow Pump
No. of main Pumps	3
Unit Capacity	1,700 m³/min (60,040 ft.³/min)
Total Head	8.25 m (27')
Impeller Diameter	2,700 mm (8.86')
Motor Output	2,800 kW 200 rpm (Umbrella-type Vertical Synchronous Motor)

Hitachi, Ltd.
Tokyo Japan

Cable Address: "HITACHY" TOKYO

"Bracing" weather for pipework



Shocks and vibration give rise to high stresses in pipework, with possible subsequent damage to piping and associated equipment. Pipework on board ship subjected to vibration or in land installations exposed to high winds, is particularly prone to these hazards.

Vokes Genspring Non-Resonant Sway Braces supply an efficient form of control on all such pipework. These Sway Braces have many unique features including an incorporated energy-absorbing device, adjustability of initial restoring force, laminated cushioning material to reduce operational noise, and travel stops to prevent compression of springs to solid height. The eight different spring sizes cover loads from 39 lb. to 1,500 lb., with maximum restraining force varying from 100-2,250 lb. due to spring action.

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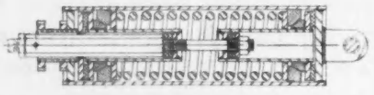
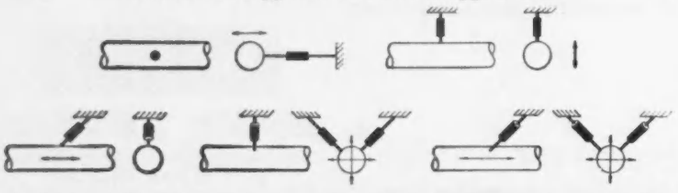


Vokes Genspring Non-Resonant Sway Braces

Sketches of suggested methods of application



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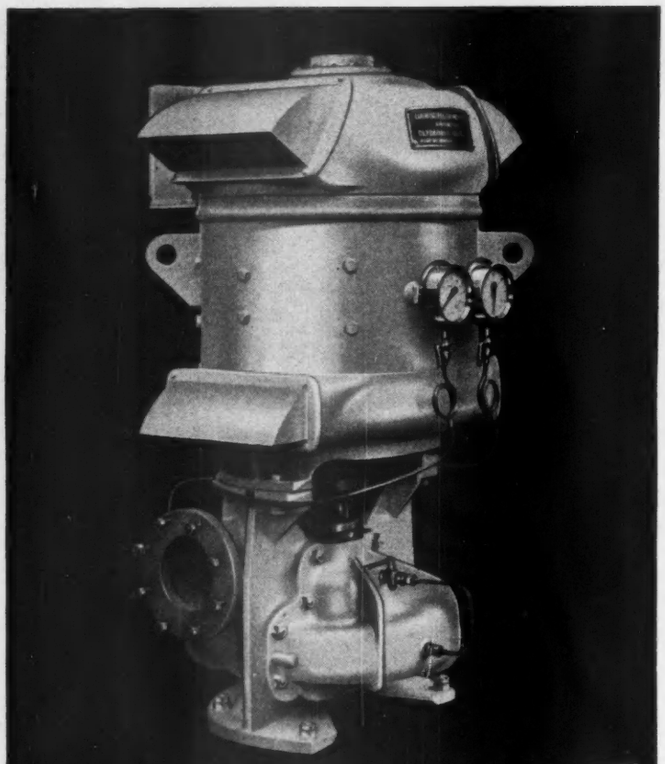

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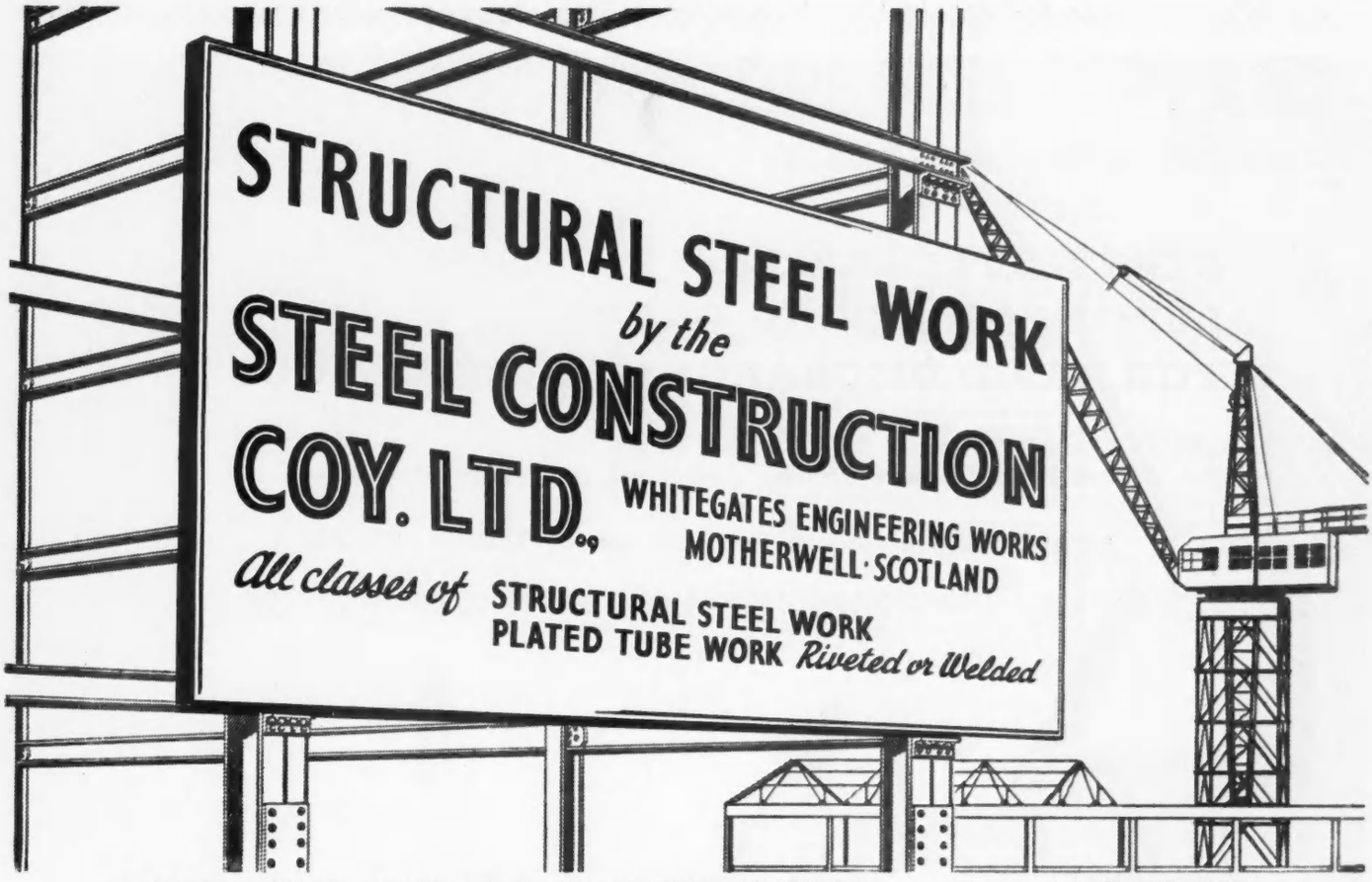

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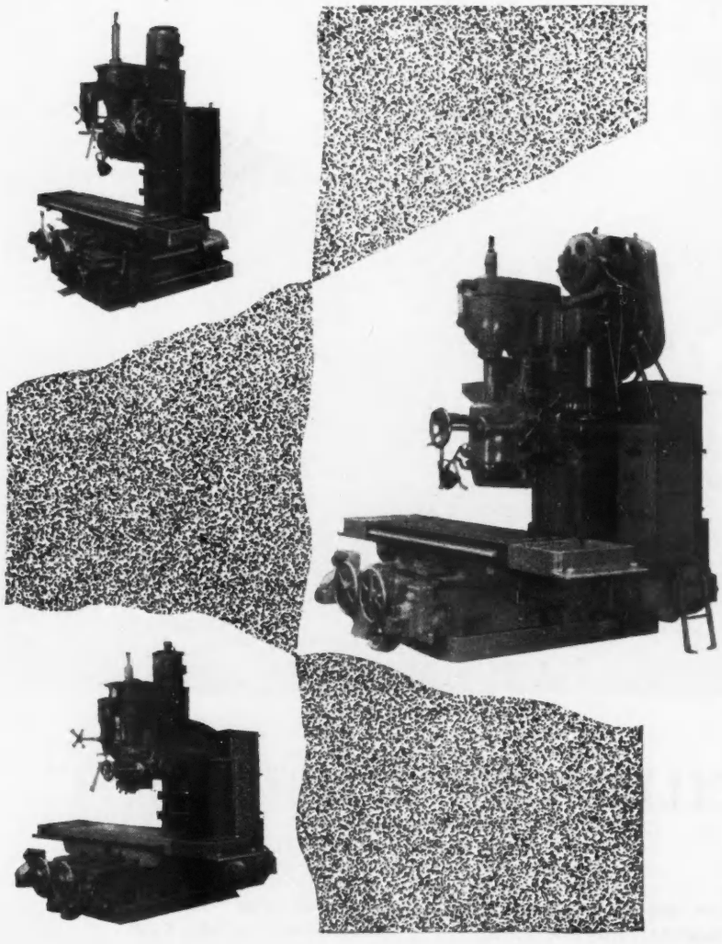

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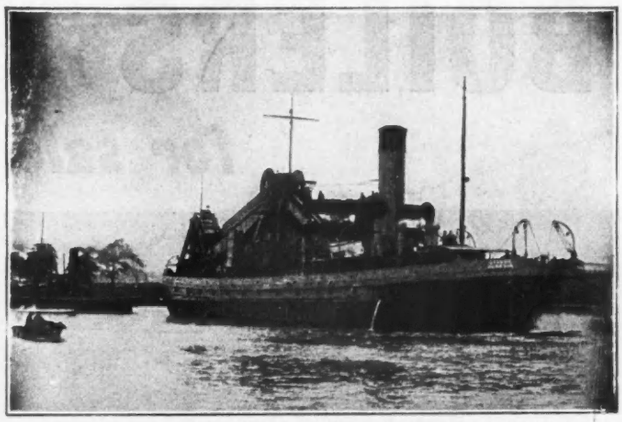

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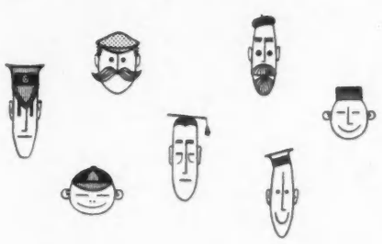

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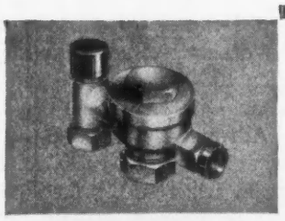

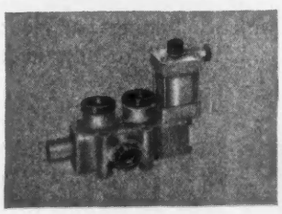

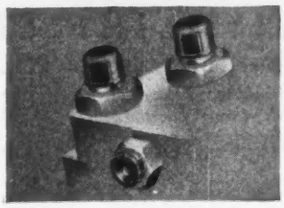

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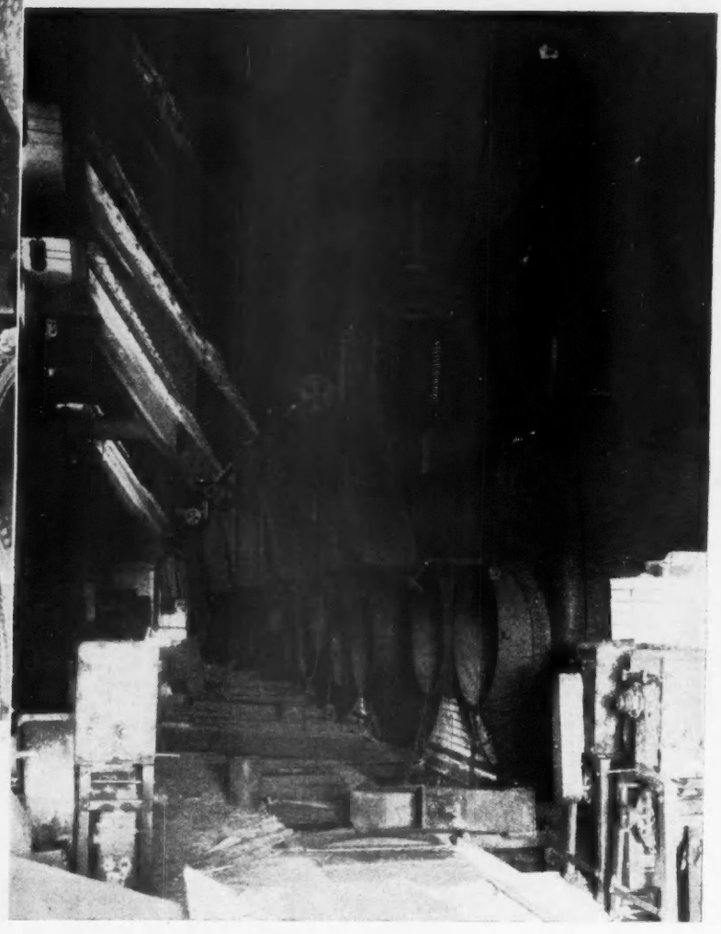

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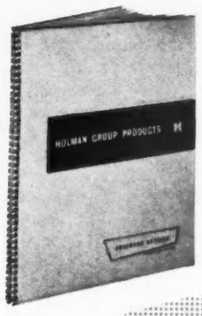

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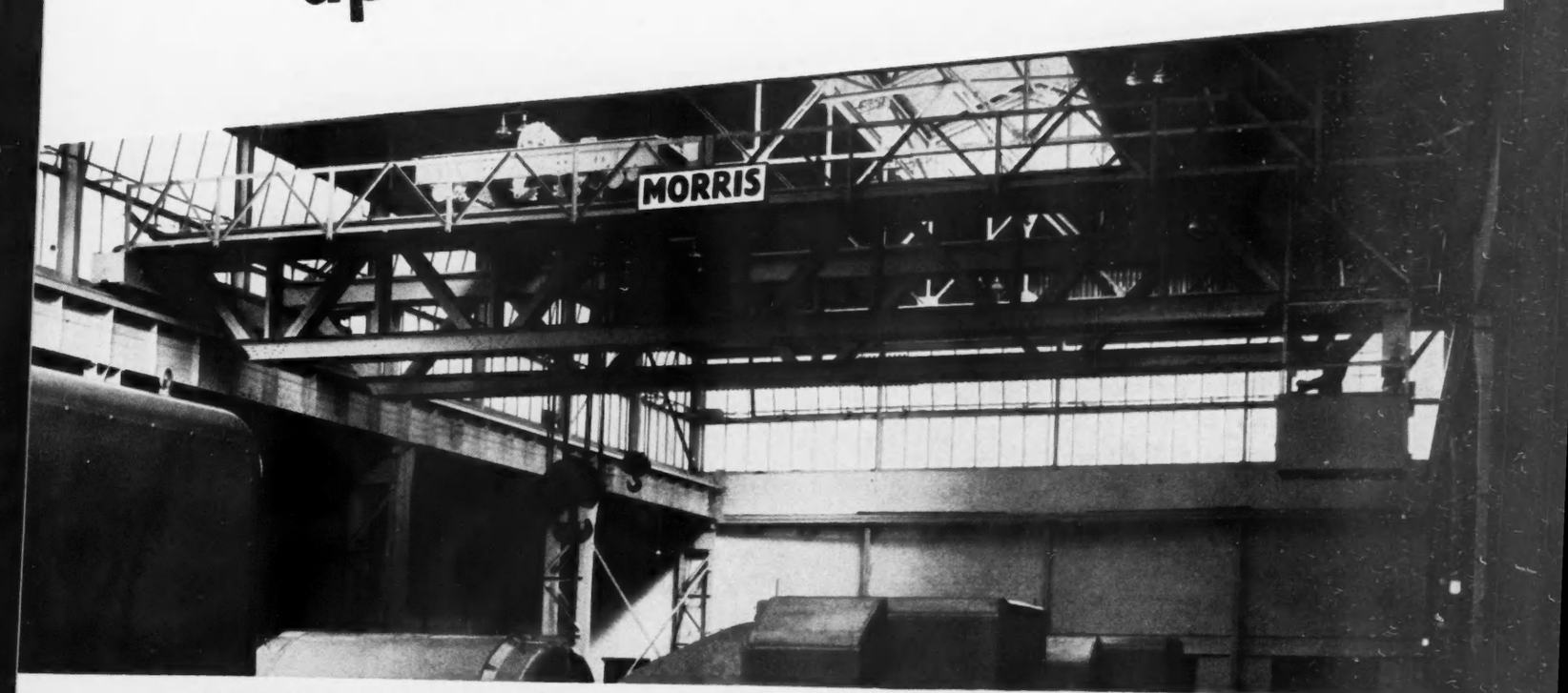

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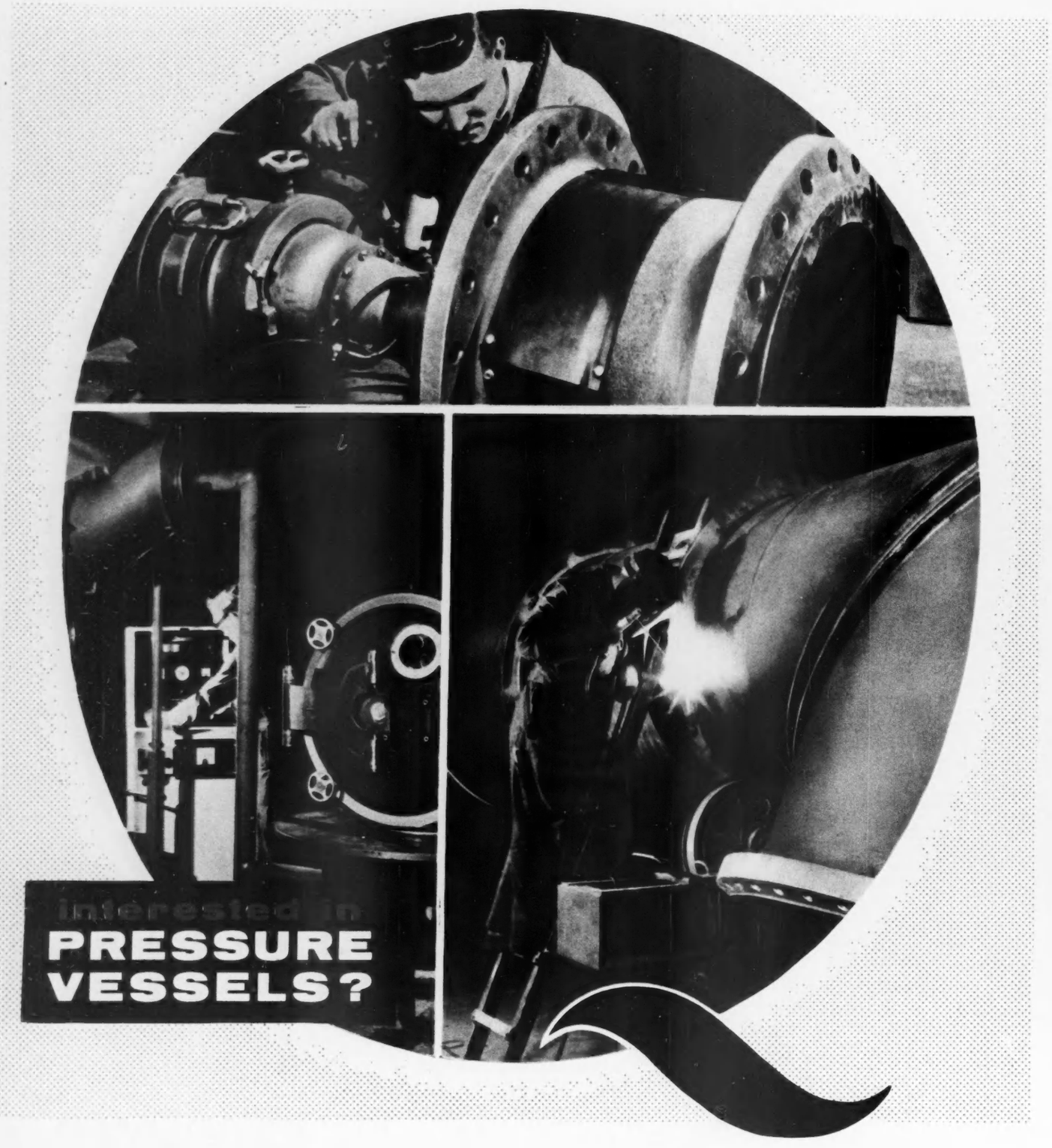

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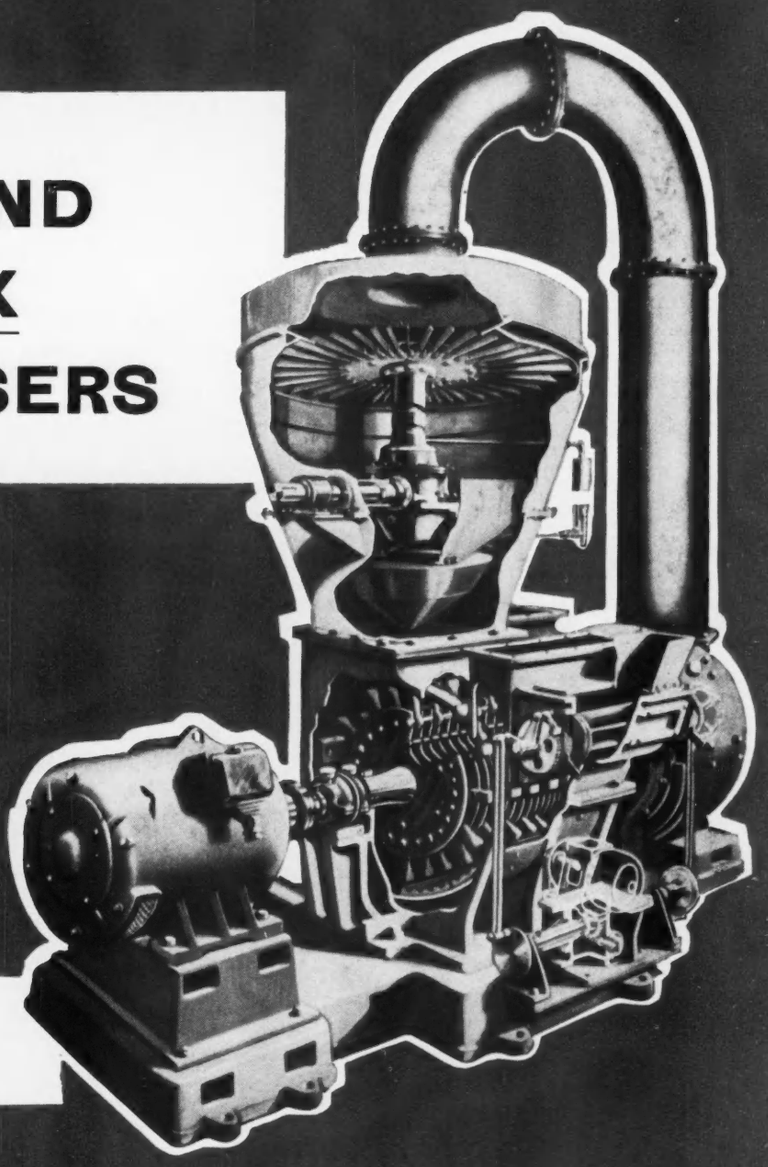

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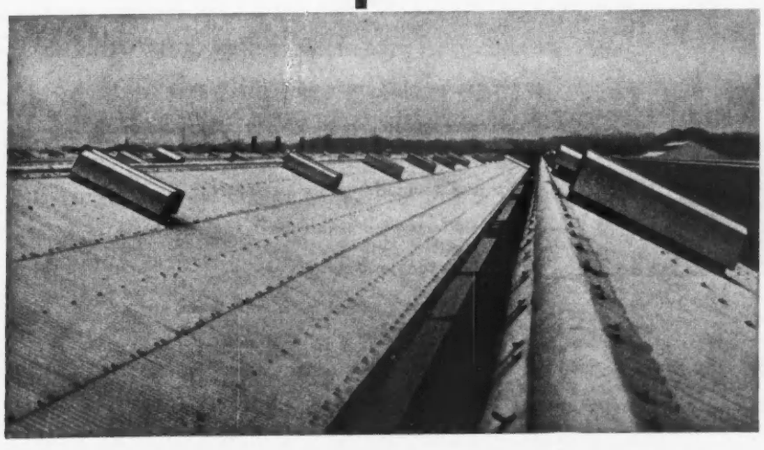

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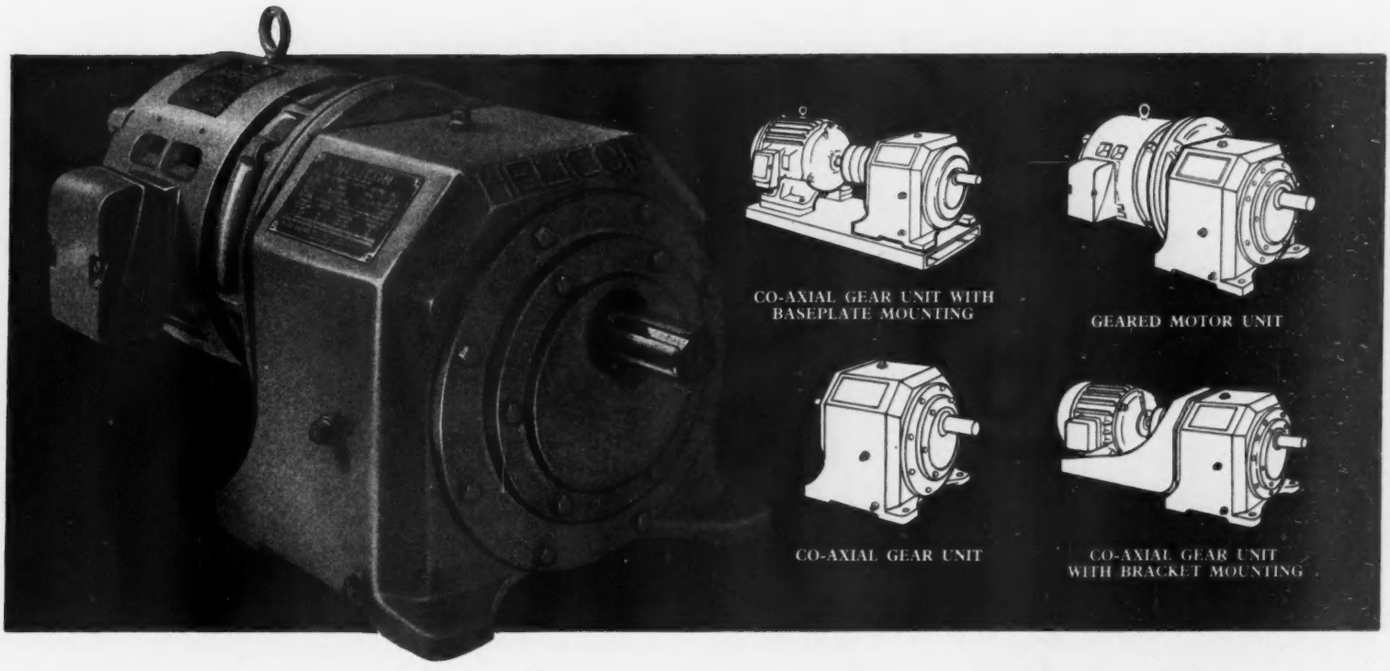
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' FIELDING ' 4,500 tons, multi-ram, upstroking plate press, designed to carry out the shaping of heavy steel plates. The press will accept the largest plates that are being manufactured by the British Steel Industry today; with a substantial margin for future development. The pit in which the press is housed is 31ft. in depth and the weight supported by the foundation is 780 tons. Hydraulic power for press operation is supplied from high and low pressure ' FIELDING ' accumulator systems, the high pressure circuit being powered by ' FIELDING ' H.3 type three throw pumps.

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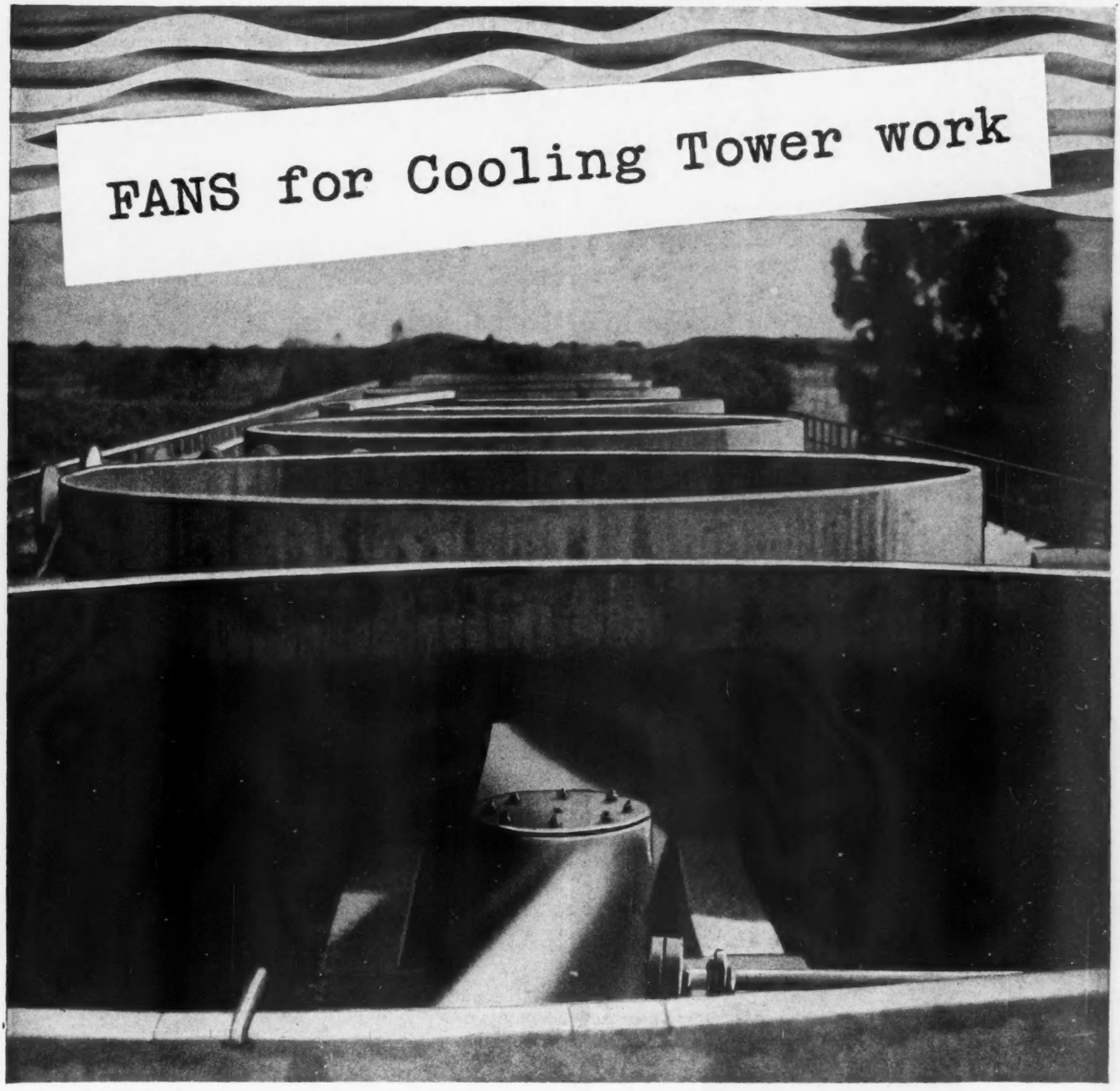

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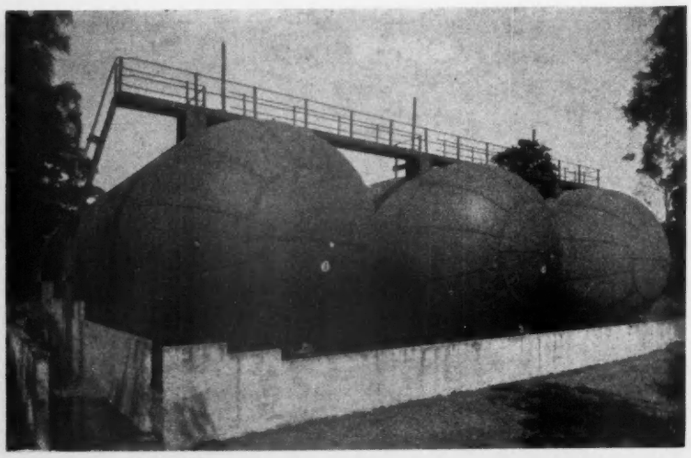

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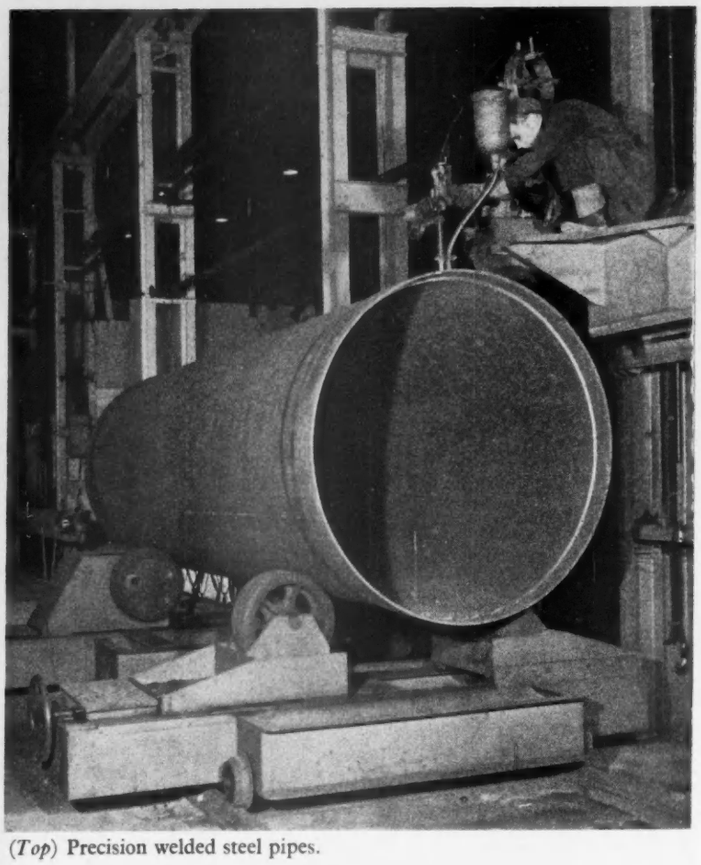
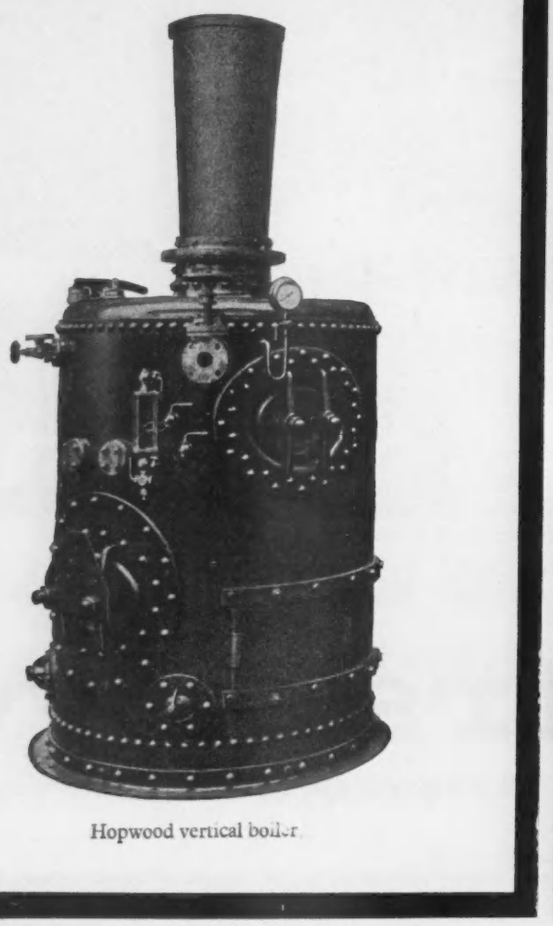
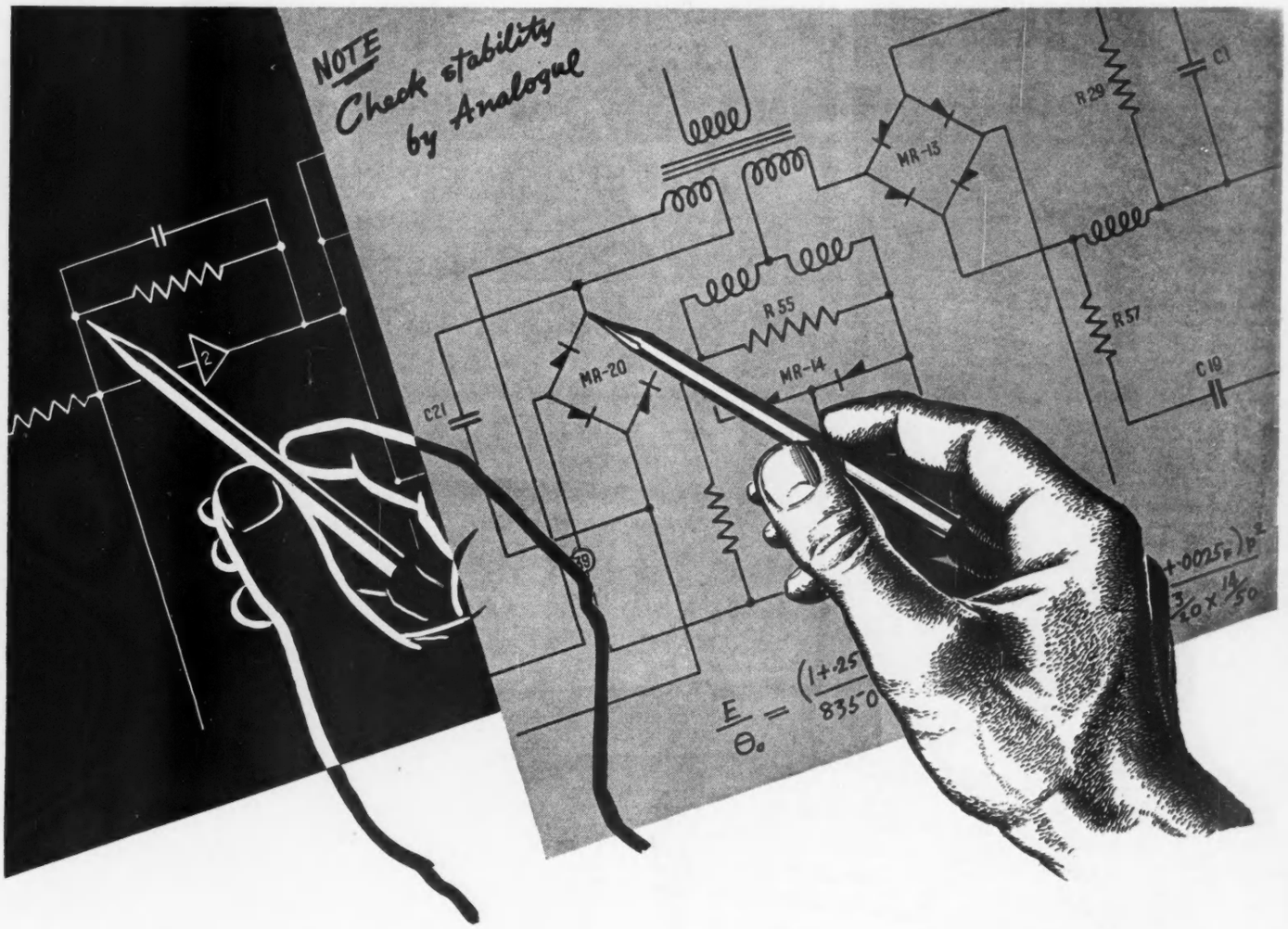


(*Top*) Precision welded steel pipes.

(*Below*) Concrete lined and sheathed pipes.



Hopwood vertical boiler



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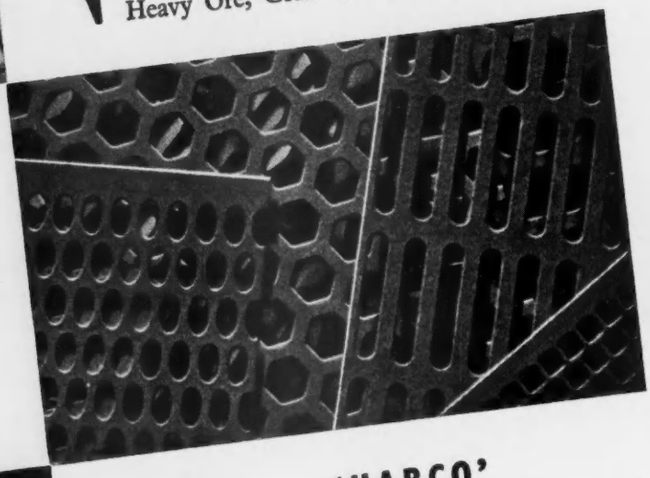

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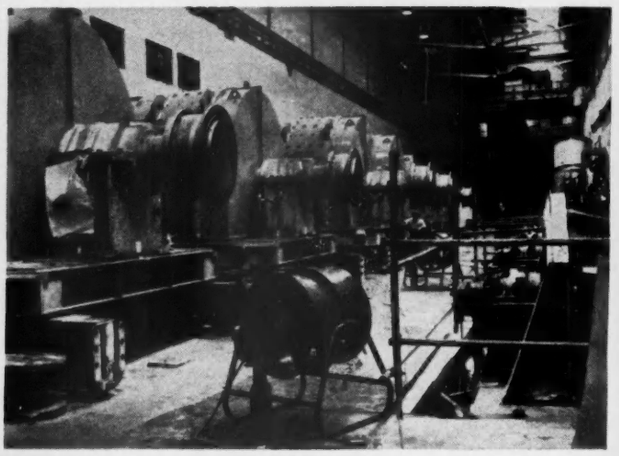
Target beaten in

At the Ebbw Vale Steelworks of Richard Thomas and Baldwins Limited re-motoring of the continuous hot strip mill was accomplished in only 19 days—one day ahead of schedule. This operation involved the removal of 1,500 tons of equipment and its replacement by new machinery.

The G.E.C., as the main contractors for the finishing mill electrical work, operated in close collaboration with Richard Thomas and Baldwins Limited and the Consulting Engineers, McLellan and Partners. The contract covered the supply and erection of the main drive motors, rectifiers, transformers, d.c. circuit breakers and all protective, control and instrumentation equipment for the finishing mill.



1. With the new, more powerful motors lined up behind the old, and with much of the associated equipment already installed, everything was set for the changeover.

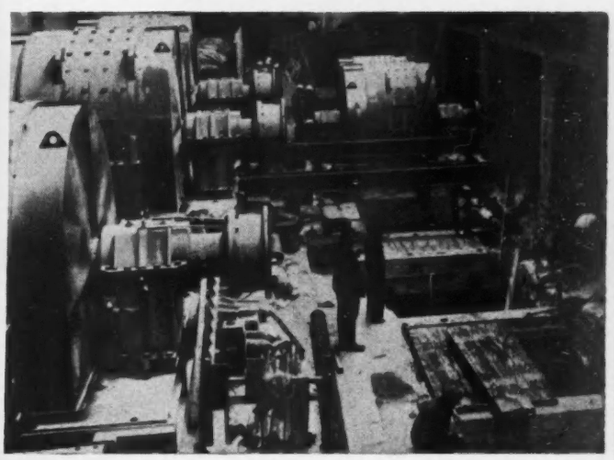
4. The mill couplings were then fitted. The new total of 23,000 horsepower will give the finishing mill a substantially higher output than the former capacity of 16,000 tons per week.

5. From the new, wide-view pulpit, the operators control the rolling operations. The mill voltage is automatically set up and checked by means of indicator lamps which show when each operation in the sequence is complete.

G.E.C. OF ENGLAND

mill re-motoring

2. Work started at 9 a.m. on August 1st, within minutes of the last strip passing over the run-out table, and foundations were quickly prepared for the new machines.



3. Work went on all round the clock. Winches were used to slide 480 tons of motors on heavy beams across the motor room and the machines were lowered on to the foundations.

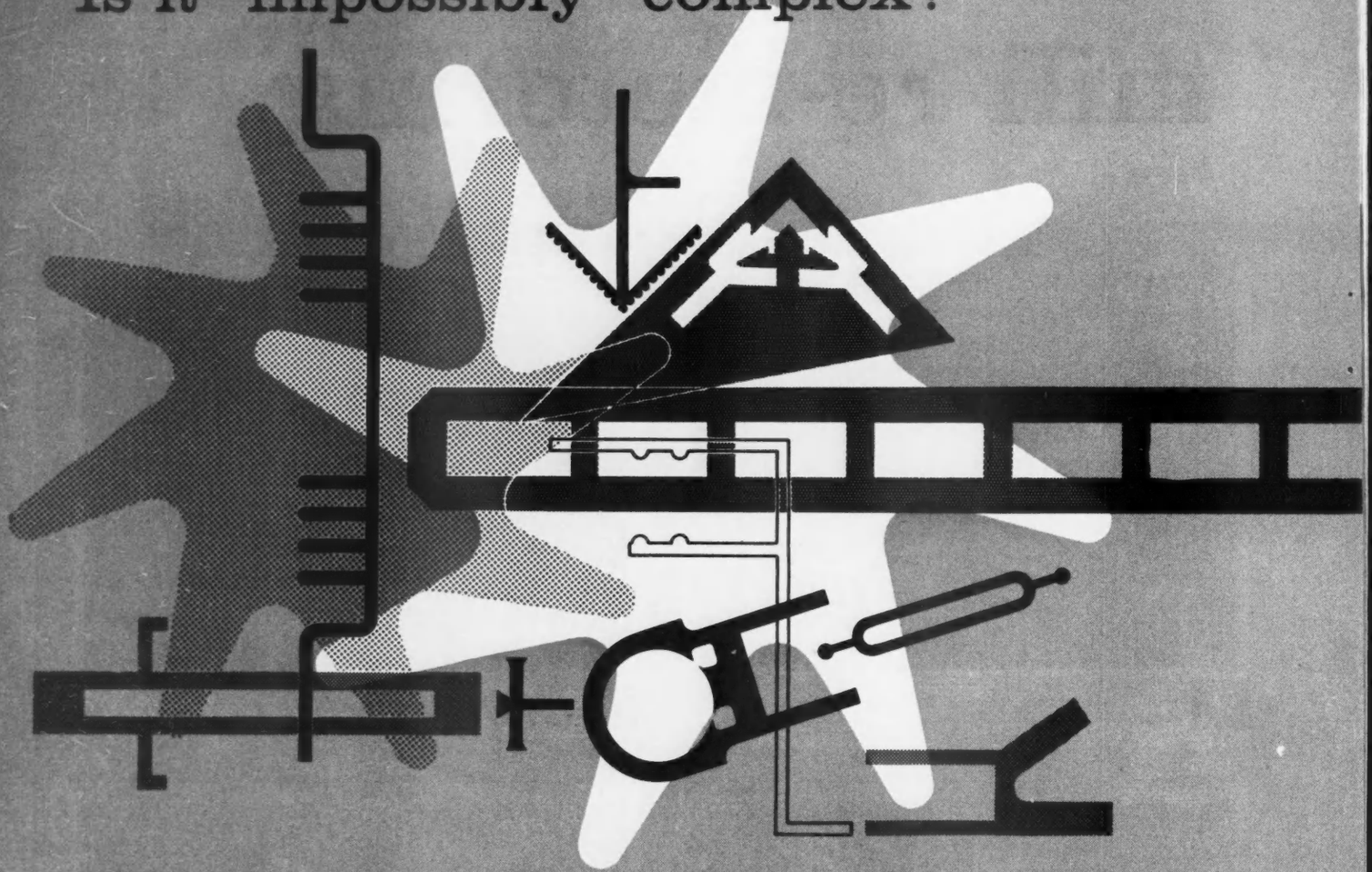
6. At 12.40 p.m. on August 20th the mill commenced rolling, so bringing the changeover to a successful conclusion in record time.

7. More than 60 tons of busbars and cables link the motors, the control gear and 19,800 kW of grid-controlled rectifiers which provide power for the finishing train.

THE GENERAL ELECTRIC COMPANY LIMITED OF ENGLAND

Plant Co-ordination Division, Birmingham, 6

Is it "impossibly" complex?



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Manufacturers in many fields—from automobiles to atomic power—know where to take their worst headaches: H.D.A. have a way with really disheartening problems that turns them into feathers in the caps of all concerned. Our Hiduminium extrusions are an example. They combine smoothness of surface and a uniformly fine, dense structure with the highest physical properties. They have solved many manufacturer's problems—thanks to the special treatments evolved by H.D.A. to make one of their Hiduminium alloys precisely suitable for a particular application. Problems like this are always cropping up. H.D.A. is always solving them.

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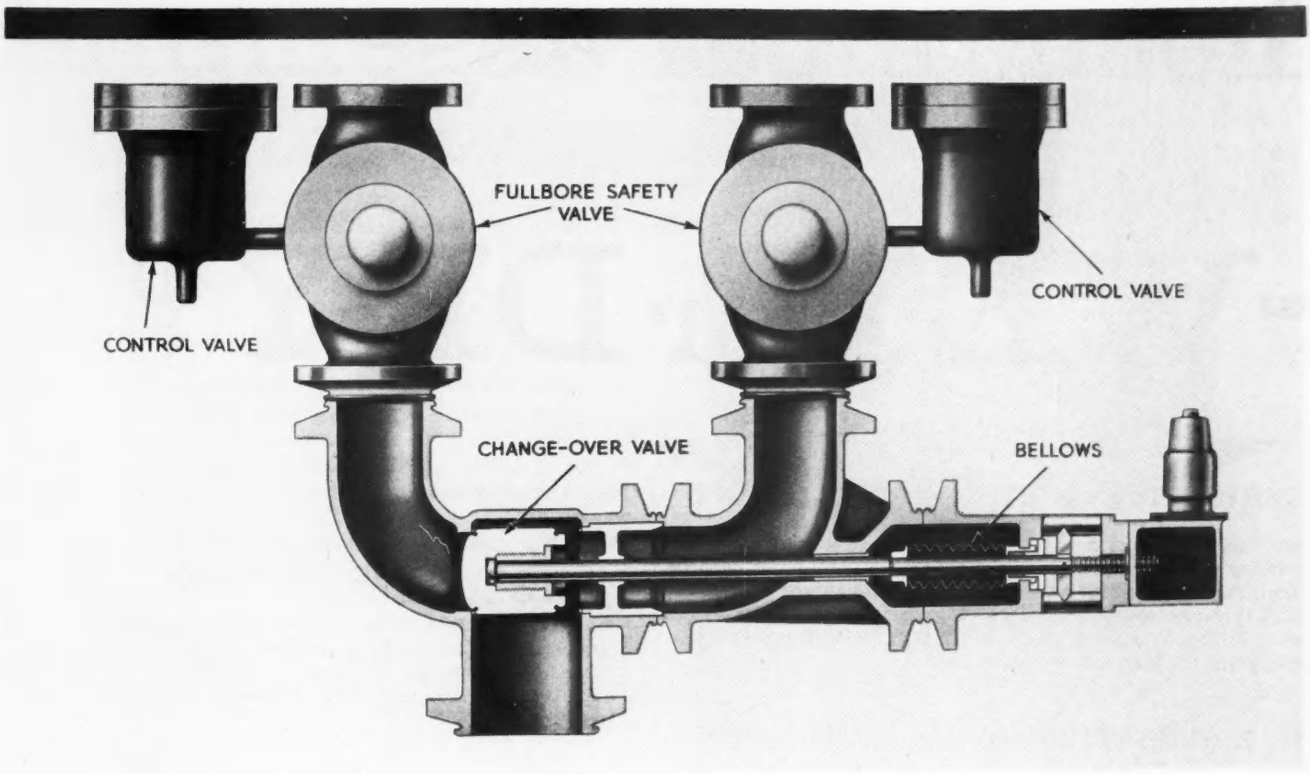

Cockburns are supplying five sets of combined Change-over and safety Valves for radio active CO_2 gas service in the Advanced Gas Cooled Reactor at Windscale.
In selecting Cockburns design Valves for this service the U.K.A.E.A. were drawing on experience of Valve Manufacturing covering almost 100 years.

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-WET or DRY?

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Every time a designer puts pencil to paper to sketch an assembly of moving parts he works within a constraint which has become so familiar that he scarcely recognises its existence. This constraint is the necessity to provide oil, grease, graphite or pressure lubrication for all sliding surfaces. GLACIER DU Bearings break this constraint. They never need oiling!

DU: A SENSATIONAL BREAK-THROUGH

DU Bearings have been described in America as "a sensational break-through in bearing technology". The reason for this is that although dry bearing materials had been in use before—process industries and extreme-temperature-duty applications, for example—until GLACIER developed DU, no dry bearing material had been discovered which combined such low friction with such high resistance to wear and great mechanical strength. DU Bearings for the first time widen the scope of dry bearings to include almost every application. They were originally developed —and are made exclusively—by GLACIER.

WHAT IS DU?

DU, the material from which GLACIER DU Bearings are made, consists of a tin-plated steel backing on which a thin layer of porous bronze is laid. This is impregnated with a mixture of lead and a fluorocarbon known as FLUON*. DU combines all the advantages of these materials, including resistance to wear, low friction and anti-adhesiveness, high thermal conductivity, low thermal expansion, high mechanical strength, wide service temperature range—from −200° to +327° C.—resistance to abrasive atmospheres, elimination of contamination, and the ability to run submerged even in corrosive liquids—often with improved performance. Its lasting powers are excellent; it can carry heavy loads at high speeds; it requires no attention and of course no oil whatsoever.

DQ SOLID FLUON MIXTURE

GLACIER DQ solid moulded FLUON mixture is available in tubes and rods up to 2" dia. and 7" long. Unlike DU it can be machined all over to make difficult or very small shapes. It is a homogeneous mixture and is therefore less sensitive to edge loading and some types of corrosion than DU.

PROVED IN OPERATION

For a number of years GLACIER DU and DQ Bearings have been very successfully used in a number of specialised applications. There are nearly 400 of them in each Comet. Other users include such distinguished names as de Havilland, Rolls-Royce, Courtaulds, Jaguar, E.M.I. and Metropolitan Vickers. But through the mechanical field there are more applications for DU and DQ. Dry mechanical assemblies are now a possibility to be borne in mind by every designer. GLACIER DU and DQ Bearings can bring about tremendous savings in design, cost and maintenance.

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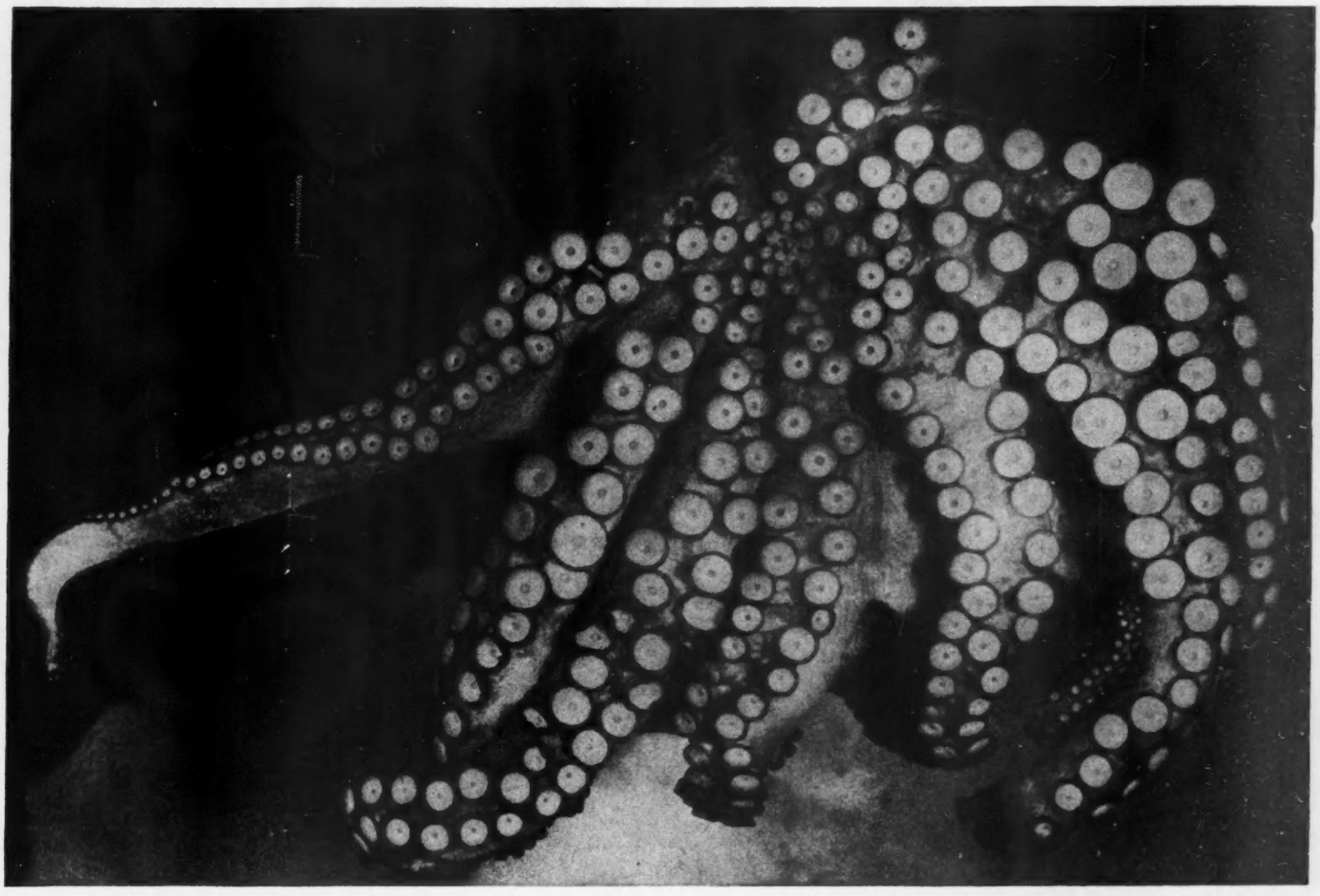

Man-made Octopus

Octopus-like, this KING installation at the Banbury Works of the Northern Aluminium Co. Ltd., manufactured in collaboration with Millars' Machinery Co., Ltd., Vacuum Division, Bishops Stortford, handles aluminium slabs 90 ft. long, 7 ft. wide, ½ inch thick; octopus-like—by tentacles and suction. 44 suction pads are suspended from the lifting beam manifold, each having an automatic cut-off device to prevent loss of vacuum when shorter slabs are required to be lifted. All this is remotely controlled by one operator—yet another example of the superb ingenuity and efficiency of the KING approach.

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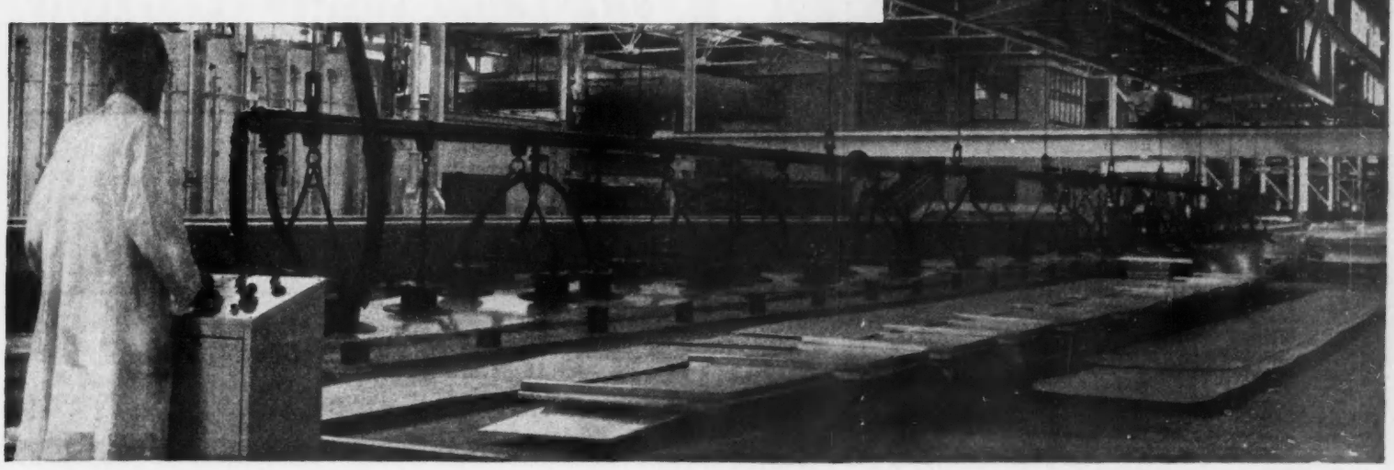

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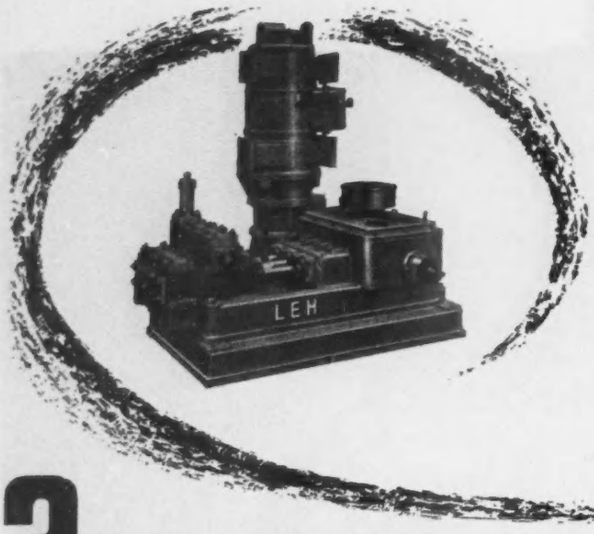

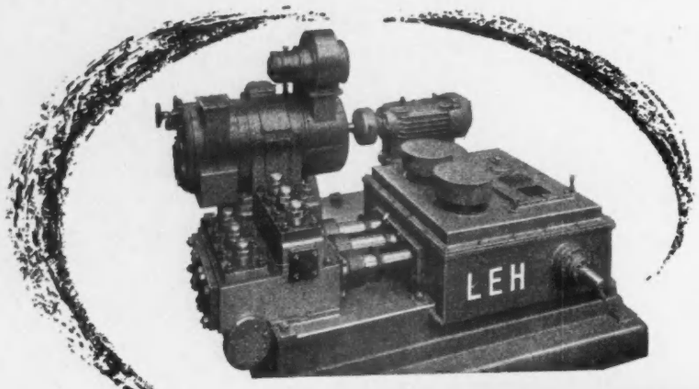

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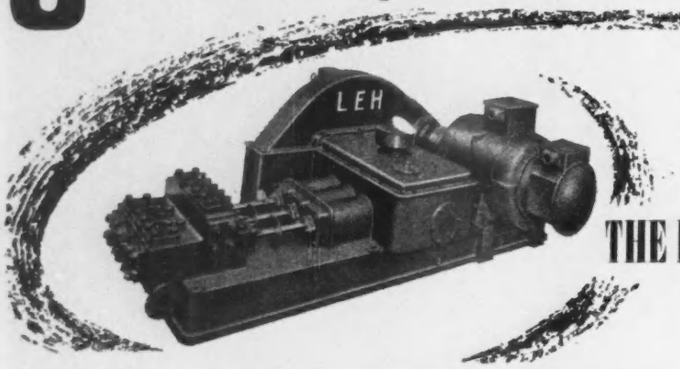

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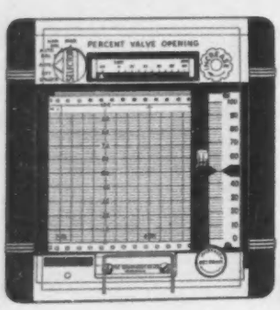

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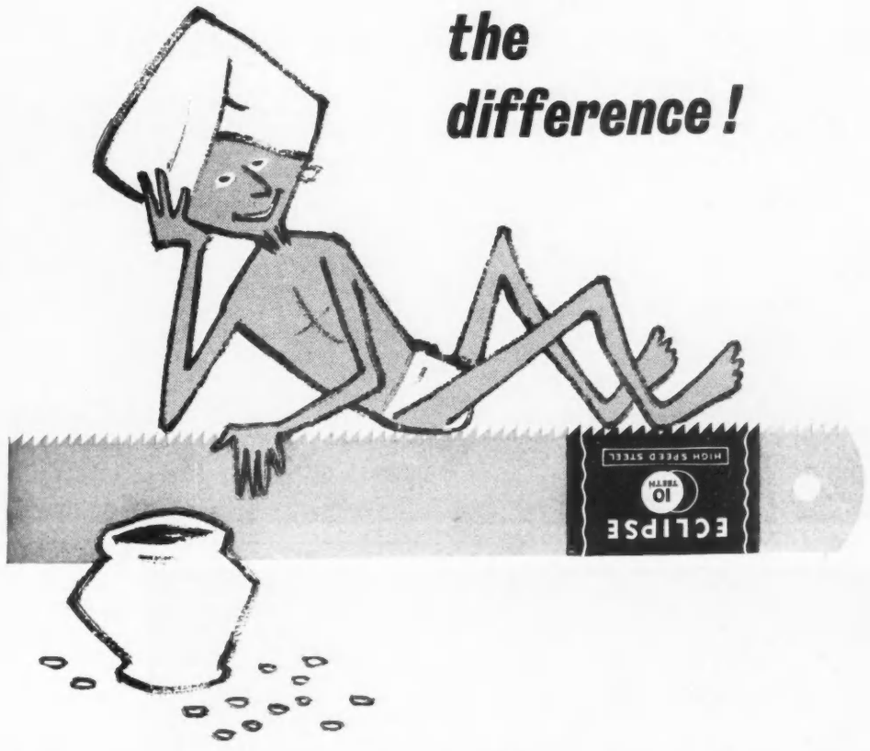

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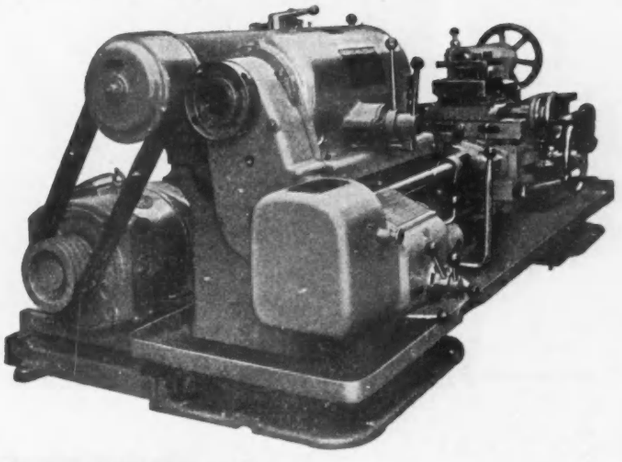

The photograph shows one of our drives mounted on a Denham Model SS8 heavy duty centre lathe.

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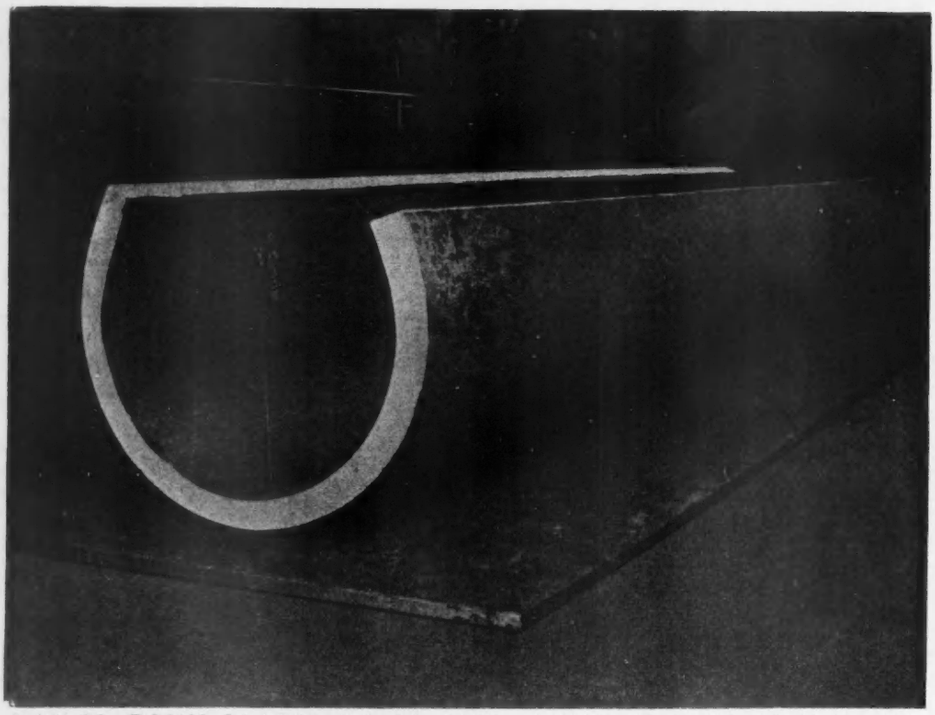

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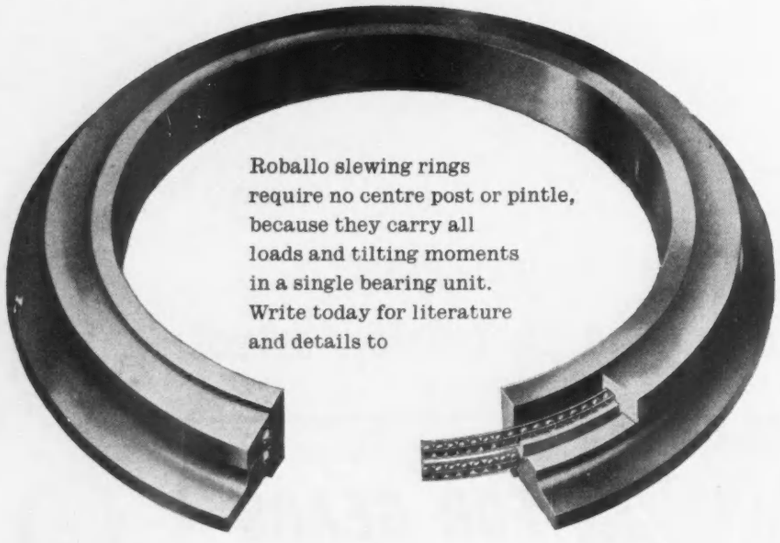

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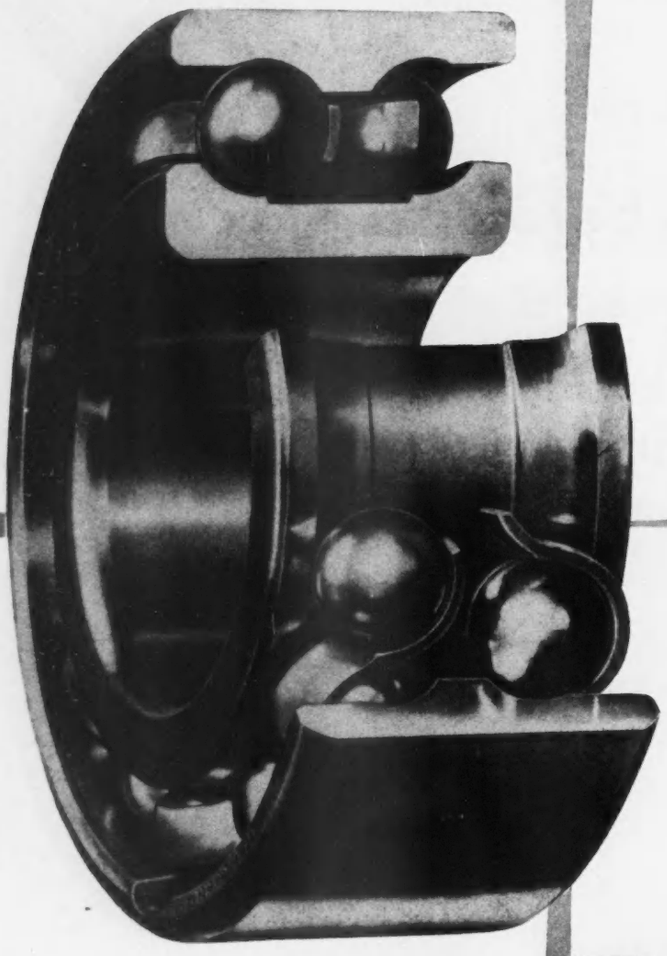

In the various applications of rolling bearings, the double row angular contact ball bearing is useful where the displacement of a shaft subject to axial loads must be kept within very narrow limits. The ball tracks in bearings of this type are disposed so that the load paths through the balls intersect the shaft centre line outside the bearing.

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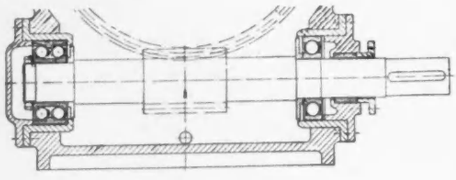

Worm shaft of worm gear unit

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ENGINEERING Impact

of Steel at Home and Abroad

British steel exports in the third quarter of 1959 (4,163,000 tons) were at one of the lowest levels of the last three years, yet by an ironic turn of the world market were the highest proportion of total world exports, 16·1 per cent, of any quarter in that period.

The United States exports, decimated by the steel strike, fell to 6·4 per cent. Since reaching 28·2 per cent of the total in 1957's third quarter, United States' steel exports have steadily declined in significance to well under half that figure.

The contraction in orders for rails and railway material is by no means confined to Great Britain. The latest return from the Iron and Steel Board shows that over the past year this contraction has been going on all over the world.

British steel production in 1959 was running much more strongly at the close than the all-year figures show. Over the whole year output, in 52 weeks, was 20,200,000 tons, as against 19,600,000 tons in the 53 week 1958. Steel making capacity was working up to 83·8 per cent in 1959 and up to 82·6 per cent the year before. Weekly average production in 1959 was very little more than in 1958.

In fact, at the close of the year, steel making was going on up to 95 per cent of capacity and the weekly average production in December was 432,900 tons, 38 per cent above the rate 12 months before.

The Iron and Steel Board estimates that additional capacity in 1960 will raise the total to a possible output of 25,500,000 tons and that the actual output will probably be 24,000,000. Leaving aside the final and holiday week of December, the average output of the first three December weeks was 474,300 tons, keeping up the 3 to 4 per cent rise a month begun in October.

Decline

For all the consumer goods boom and its parallel improvement in machine tools and general engineering, there is an unhappy assembly of statistics in the traditional heavy sector of the economy. Deliveries of finished steel for railways and rolling stock, October-November, 1959, were 57·9 per cent less than in the same two months of 1957. Deliveries to the coal mines over the same period dropped by 34·4 per cent and to shipbuilding and marine engineering by 37·1 per cent. The biggest rises over the two years were of 18·8 per cent to motors, cycles and aircraft, and 15·5 per cent to stockholding merchants.

Thus a section of the steel industry needs the brake to be taken off modernisation of the railways in order to enjoy a revival, coal is unlikely to help in this. Yet the Government is hardly likely to be looking round for a method of pushing the present prosperity further towards inflation, which is perhaps what stimulating heavy capital expenditure might do.

European Steel Challenge

The steel output of the European Coal and Steel Community companies was rising almost as fast as in Britain. The British average December weekly output was 29·6 per cent more than the year before; in the ECSC steel companies the December production of 5,622,000 tons was 22 per cent above the output of December, 1958.

Total output of steel ingots and castings from the Community in 1959 was 63,142,000 metric tons, almost 9 per cent more than the previous year. Pig-iron and ferro-alloys were also at a record level of production reaching 3·5 per cent more than the former record year, 1957.

Despite the quickening of industrial activity within the Community, pithead coal stocks continued to grow. Coal production last year was 234,880,000 metric tons, almost 5 per cent less than that of 1958. Market conditions are still difficult.

The Community's share in the total world steel exports goes on steadily creeping up. In the third quarter of last year it had reached 69·6 per cent. In the second quarter of 1957 it had been 55·2 per cent.

Imports Ahead of Exports

Imports into Britain in 1959 increased slightly more over the year than did exports. The final Board of Trade figure for British exports last year is £3,326 million, which is 5 per cent ahead of depressed 1958 and 1 per cent ahead of the previous best, which was 1957. Imports last year were £3,993 million, which was 6½ per cent more than in 1958 but 1 per cent less than in 1957, which suggests that the terms of trade and the amount of home consumption are still slightly in our favour, but not as much as they were in 1957.

After making its seasonal adjustment the Board of Trade concludes that exports in the last quarter of 1959 were up 5½ per cent on the previous quarter but that imports rose by 8 per cent. This brings us back to the familiar post-war position where either there will have to be much greater success in the export markets or before long Mr. Heathcoat Amory will be prophesying crisis, marking up the Bank Rate and generally damping out the consumer boom.

The December (corrected) export figure was £292 million, and the imports in that month cost £359 million. Re-exports were worth £11 million.

Structural Steelwork on the Attack

Something of a revolution in structural frames for buildings is to be expected with the introduction of a light weight fire protection for steelwork. Hitherto, it has been necessary to encase the steel sections in concrete to obtain adequate "fire resistance." This has involved all the paraphernalia of shutterwork that has contributed so largely to the higher overall cost of steelwork as compared to that of structural concrete. Lightweight casings will lead to reduced dead loads and smaller foundations and also to easier site working.

Vermiculite plasters are now to be marketed for encasing steelwork. A detailed report *Lightweight Fire Protection for Structural Steelwork* has been prepared by Frederick S. Snow and Partners, the London consulting engineers. Their work was sponsored by the British Constructional Steelwork Association, Mandoval Limited (suppliers of vermiculite) and the plastering industry.

The savings forecast for the use of the new protection are equal to the price advantage now held by reinforced and prestressed concrete. With the gains to be made by using broad flange sections, and the promise of mechanisation in the plastering industry, the resulting picture looks like a swing back to structural steel for buildings, displacing concrete from the lead it has held these last ten years.

of Regrouping the Aircraft Industry

If aircraft designers had depended on ordinary sources of capital and profits to finance their work during the past ten years, the rate of technical progress would have been much steadier. But military and prestige reasons have favoured a hothouse of development. We continue to be committed to Government aid for the industry.

Only two years ago, when the White Paper on defence was issued, manned military aircraft were regarded as finished and all support was to be given to guided, ballistic and nuclear weapons. Now in 1960, though manned military aircraft are still back numbers, we are putting our money into supersonic airliners. The money still goes straight to the aircraft manufacturers, as it did for military aircraft development contracts. But is the situation comparable? Would it not have been better to give the money to the users, i.e., the airlines, and let them do the awarding of contracts?

In the meantime, the Nation loses when a designer as brilliant as Mr. W. E. W. Petter decides to leave the aircraft industry and the country. Though he has personal reasons for going, his letter, published in this issue, expresses his anxiety for the future of the industry.

If ENGINEERING were to hazard another prophecy, it would be that within a few years one or two new aircraft firms with bright ideas and some hard-won capital will spring up and operate alongside the giants.

Britain in Moscow 1961

More than one opinion on the future of British trade with Russia is heard at any discussion on exports, but the rapid acceptance of space at the British exhibition in Moscow next year by UK industry suggests that many firms feel that if there is to be a market in the Soviets they are going to be in it.

The two reciprocal fairs will be in Moscow, from 19 May to 4 June 1961, and, by the Russians, in London at Earls Court during the following 7 to 29 July. At Earls Court the Soviet exhibition will cover 250,000 sq. ft and will show both capital and consumer goods. The British exhibition will be held in the Sokolniki Park of Culture and Rest, using the Glass and Dome pavilions erected for the American exhibition early last year. The demand for space from British industry has compelled the organisers to plan temporary structures outside the two domes for Industrial and Trade Fairs Limited.

Parallel Growth of Ford and B.A.

Two organisations that in many ways have strong similarities have recently been seen to be both growing strongly.

They are the British Association for the Advancement of Science and the Ford Foundation. Decisions taken two years ago this month are bearing fruit for the British Association. Where there were once three area organisations there are now 15, one of them serving the Western Islands of Scotland.

This year's annual meeting will be at Cardiff from 31 August to 7 September and Sir George Thomson, F.R.S., who takes over as president from Sir James Gray, F.R.S., is to deliver his address in "*The Two Aspects of Science*." It is Sir George's contention that it is at least as important that as many educated people have the same appreciation of science in future that they have now of literature as that the number of grammar and public school children with science as their main interest should be increased.

Unless Sir George has a very rosy impression of most people's reading habits this would seem to lead to a concentration upon biology with accountancy a close second.

The Ford Foundation spent £42,500,000 in support of 11 human welfare programmes in the year up to 30 September, 1959. The Foundation's financial affairs have been moving in two directions. Increases in the stock market value of Ford shares has carried the Foundation's net assets up to $3,100 million, against $1,900 million a year earlier. At the same time, because of a decrease in dividends, the income fell from $92 million to $84 million.

and Electrical Exports to Canada

In the ten year life of the joint approvals agency operated by the British Standards Institution and the Canadian Standards Association, manufacturers have come to accept that there is virtually no alternative to obtaining prior approval before exporting electrical equipment to Canada.

This conclusion is reached in the the BSI report on the joint agency.

Although the cost of carrying out the agency's work in Britain has gone up slightly over the last two years the charges at the Canadian end have been reduced and the final result is that charges have stayed more or less the same.

With the rate of applications for approval growing there are now about 220 approved electrical items. New engineers have been appointed and trained, work connected with some BSI-Kite mark schemes has been undertaken and a better load factor and greater efficiency achieved.

Reducing the Permeability of Graphite

Graphite has been made highly impermeable and suitable for canning nuclear fuel elements. Impregnation with furfuryl alcohol can reduce final permeability to the low value of of 5×10^{-9} sq.cm per second.

By W. Watt, B.Sc., A.R.I.C., R. L. Bickerdike,* B.A., and L. W. Graham,† B.Sc., Ph.D.*

The limitations imposed by suitable nuclear cross-section and moderating properties have restricted the choice of materials for use in high temperature nuclear reactors to a few which in themselves have rather poor engineering properties. One of the most severe materials problems is the gas-tight fuel can designed to prevent fission products diffusing into the coolant circuit and capable of operating at 800° C and above. Graphite which would be excellent from a nuclear viewpoint suffers from the grave disadvantage that it is highly permeable. There has thus arisen in the last few years an engineering requirement for impermeable graphite of sufficient importance to justify detailed study of ways of producing this material. The methods described below have been developed for the high temperature reactor originally studied by the UKAEA and now being investigated by the OEEC Project Dragon and they have resulted in large reductions in permeability, i.e. in a material which is almost vacuum-tight.

Graphite belongs to the small group of engineering materials (silicon carbide is another) which cannot be made impermeable by metallurgical methods. The graphite crystal consists of tightly bound hexagonal arrays of carbon atoms in planes between which there is only a residual bond of the Van der Waals type. This results in a large variation of thermal expansion with crystal direction and very low cohesion along the hexagonal axis. Even if one could melt graphite conveniently (which is precluded by the high carbon vapour pressure) it is doubtful if a large mass free from faults could be obtained. Hot working is unpromising because of the anisotropy just mentioned and the relatively high strength at elevated temperatures; also the material does not sinter in the commonly accepted sense. The industrial method of making graphite by bonding coke particles with pitch, and then heating to a high temperature to carbonise the binder and later graphitise the product leaves a network of irregular pores in a range of sizes, some being closed pores while the majority are connected pores. It is the latter which give the product its permeability, and they constitute about 14 to 20 per cent by volume in a typical high grade graphite. We are left with the possibilities of blocking these by an impregnation process, or of forming external layers of impermeable material by a deposition process.

GAS PENETRATION

Work on the deposition of carbon by the pyrolytic decomposition of hydrocarbons on a hot graphite surface[1] has shown that the deposit produced at temperatures in the neighbourhood of 2,000° C is of almost theoretical density and is more or less gas tight. This is not a good technological solution to the impermeable tube problem however, because the coatings are highly oriented with the hexagonal graphite planes mainly parallel to the underlying deposition surface; consequently they flake off easily from the substrata as a result of expansion stresses. A more satisfactory result is obtained if the deposit is formed within the pores.

Carbon can be deposited on solid surfaces from a wide range of carbon-containing gases, and the deposition can be arranged to take place in the pores of a specimen either by establishing a pressure difference across it, or by treatment at a uniform pressure at a temperature such that the reactant can be carried into the pores by diffusion before decomposing. Watt first suggested that such a process might be possible from consideration of the work of Tesner[2]. The latter process is simpler and is the one with which we are concerned here. If we heat a piece of fine grain commercial graphite in an atmosphere containing a few cm of Hg pressure of benzene vapour to a temperature above 900° C, an external coating of deposited carbon is produced.

If the experiment is repeated at successively lower temperatures it is found that the deposit penetrates further into the pores as the treatment temperature is reduced, until at 750° C the weight uptake per unit volume is initially independent of specimen thickness up to at least ¼ in. This is presumably because the rate of deposition of carbon varies with temperature faster than the diffusion coefficient of the reacting species, so that at 750° C the reactant molecules can penetrate deeply into the pore system before breaking down to carbon and hydrogen. The penetration of reactants into porous media is a well known problem in the action of catalysts, and a theoretical basis for this has been established by Thiele[3] and Wheeler.[4] It can be used to explain qualitatively the results quoted above, though it should be emphasised that the individual steps of the hydrocarbon breakdown are not yet fully understood (it is fairly certain that free radicals such as CH_3 are involved).

The permeability can be measured by one of several techniques involving the establishment of a pressure difference across a tube wall and measurement of gas flow through the wall, and these experiments show that a ¼ in thick tube of fine grain graphite of mean pore size about 0·5 μ heated to 750° C in a stream of nitrogen containing 21 cm of Hg pressure of benzene vapour increases in weight by about 6 per cent in 37 hours with only a small reduction in permeability; but further deposition has an increasing effect on permeability, and at a weight uptake of 8 to 8½ per cent a reduction of 10^6 times can usually be obtained giving a permeability less than 10^{-8} sq. cm per sec. The final result of a given period of treatment depends on the diameter of the largest pores; a reasonably small and uniform pore size is an advantage; with such a material there need be no measurable change in external dimensions.

As the pores become narrower the deposition becomes less uniform and towards the end of the treatment a sharp gradient of deposit is produced near the surface of the specimen, with the most impermeable material lying within 0·001 to 0·002 in of the surface. This is the main disadvantage of the process in its simple form. To obtain the most impermeable zone below the outer surface, a multistage process has to be used; one such process involves the construction of composite tubes with a liner and an outer case, treated separately and joined with a carbon cement. This has been found to produce a low permeability tube insensitive to surface removal by oxidation or mechanical means.

Gas impregnated tubes retain their impermeability to a large extent at high temperatures, and can be used as the vacuum envelopes for high temperature vacuum furnaces up to at least 2,100° C. Having a much lower total surface than graphite, the material evolves less gas on heating, and behaves more like a metal in this respect. Impregnation produces potentially useful increases in density and breaking strength, an increase in Young's modulus, and useful decreases in oxidation rate. In contrast with the furfuryl alcohol process described below, the total pore volume is not a critical factor because the decomposition products are removed continuously during the process.

It was realised at the start of this work that a process capable of giving low permeability in depth would be desirable. As an alternative to gas impregnation a method based on a liquid impregnant was also developed.

FURFURYL PROCESS

Impregnation of the graphite with a liquid capable of giving a high carbon yield in the pores was considered. One such liquid is pitch. The art of impregnating graphite with pitch is an old one and is still widely used for increasing the density and decreasing the permeability. The changes in permeability, however, are too small to be of real practical importance. The reason for this lies in the behaviour of pitch on heating: it melts at a temperature around 100° C to a viscous liquid which becomes less viscous at higher temperatures, giving off hydrocarbons and hydrogen, and leaving a coke residue. The gases of decomposition push the liquid pitch into side pores and the walls of large pores where the coke residue has little effect on the permeability. For example the permeability of a graphite of $1{\cdot}48 \times 10^{-2}$ sq. cm per sec. after three pitch impregnations was $2{\cdot}27 \times 10^{-3}$ sq. cm per sec., and after twelve was reduced to only $2{\cdot}07 \times 10^{-5}$ sq. cm per sec.[5]

A liquid is required, therefore, which can easily penetrate the pores, solidify, and on heating give a high carbon residue without passing through a liquid phase. Such a liquid is furfuryl alcohol, $C_5H_6O_2$. This compound is relatively cheap, about 2*s* 6*d* per pound, when made from waste corn husks in the United States. When treated with a suitable catalyst it polymerises into a solid resin which on carbonising gives about 50 per cent yield of carbon. During carbonising the resin shrinks by 22 per cent in linear dimensions without going through a liquid phase to give carbon of 1·3 gm per cc density. The object of polymerising the furfuryl alcohol in the pores is to give it a three dimensional cross-linked structure (as in phenol formaldehyde resin) which prevents melting on carbonising.

The process for impregnating graphite with furfuryl alcohol and subsequently converting the furfuryl resin in the pores to carbon is roughly as follows.

A polymerising catalyst is added to the furfuryl alcohol. Suitable catalysts should allow sufficient time for pore penetration before the viscosity and molecular size of the impregnant become too large for ease of penetration. The graphite tube is impregnated from one wall with the impregnant, which is then cured in the pores to the solid resin. Carbonising to at least 1,000° C with a controlled rate of temperature rise completes the first impregnation. A second impregnation is done from the other wall of the tube with curing and carbonising as before. The object of giving the tube two treatments in this manner is to overcome bursting of the graphite on carbonising due to the pressure produced by the decomposition gases. This can happen if all the pores are filled with impregnant in one operation.

Like gas impregnation the furfuryl alcohol process works best with a commercial graphite of small and uniform pore size, that is pores of less than 1 μ diameter with mean pore diameter about 0·5 μ. In general it appears that the narrower the range of pore size in the graphite

* Royal Aircraft Establishment, Farnborough.
† Hawker Siddeley Nuclear Power Co. Ltd., Langley, Buckinghamshire.

Stock to be treated the greater is the decrease in permeability. For the high temperature gas-cooled reactor) graphite tubes about 6 ft long, 3 in outside diameter and ¼ in wall thickness, with permeabilities below 1×10^{-6} sq. cm per sec are required. These are readily obtained by treatment of fine grained graphite stock of 1×10^{-2} sq. cm per sec permeability, and by modifications to the simple process permeabilities as low as 5×10^{-9} sq. cm per sec have been obtained. This corresponds to a pressure rise inside the tube of about 2×10^{-5} mm mercury per sec when pumped out and isolated, the pressure rise being measured with a Pirani gauge.

As with the gas impregnation process the strength and modulus of elasticity of the impregnated graphite is changed. Table 1 gives typical values for fine grained graphite stock after various impregnation treatments.

TABLE 1.—*Effects of Impregnation on Graphite*

	Density, gm per cc	Breaking strength, lb per sq. in	Young's Modulus, lb per sq. in
Starting material—untreated	1·70	3,150	$1·71 \times 10^6$
Furfuryl alcohol impregnated—one impregnation	1·75	4,050	$2·91 \times 10^6$
Furfuryl alcohol impregnated—two impregnations	1·76	4,460	$3·05 \times 10^6$
Gas impregnated	1·78–1·81	4,020–4,400	$3·08 \times 10^6$–$3·24 \times 10^6$

By using certain polymerising catalysts and suitable heat treatment after carbonising, a significant decrease in the oxidation rate results compared with the untreated graphite.

Some of the properties of the pore filling carbon obtained by carbonising furfuryl resin have been determined, with the following results.

TABLE 2.—*Some Properties of the Carbon from Furfuryl Resin*

Density, gm per cc	1·28
Electrical resistivity, ohm cm. after degassing at 1,300° C	$5·80 \times 10^{-3}$
Thermal Conductivity after* degassing at 1,300° C, cgs units	0·0058

* This measurement was done at the NPL by Dr. R. W. Powell and Mr. Tye.

The resistivity of the carbon is surprisingly low, only about 10 times greater than that of the untreated graphite. On the other hand the thermal conductivity is very low, being only twice that of pyrex glass. This is due to the structure. It is a non-graphitising carbon with an extremely disordered structure, unlike carbon prepared by high temperature pyrolysis, where the size and orientation of the graphite planes are such that thermal vibrations can be readily propagated to give a thermal conductivity greater than copper.[6]

Two applications of the carbon from furfuryl resin are interesting. It can be used to make graphite-to-graphite joints by gluing the two surfaces together with the resin followed by carbonising. The joint is strong, tensile tests giving a value of about 1,500 lb per sq. in, which is nearly the tensile strength of the graphite itself.

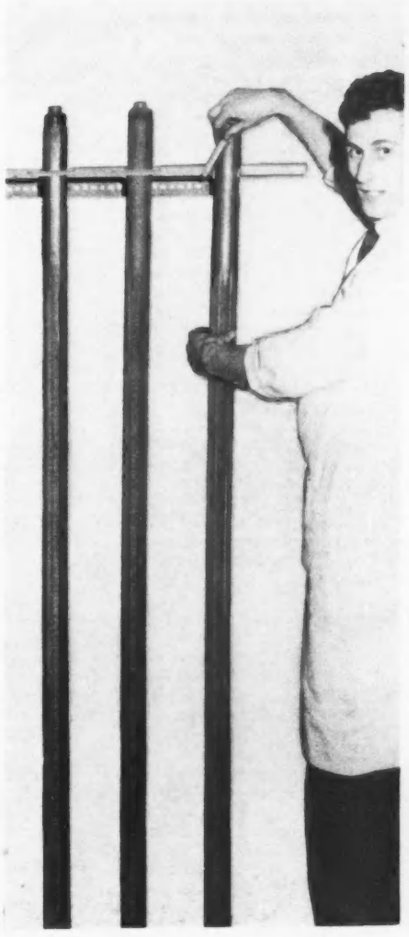
The furfuryl resin can also be used to replace pitch as a binder in the manufacture of graphite. M. S. T. Price of Chemical Engineering Division, AERE, Harwell, has used furfuryl alcohol resin as the sole binder. He has extruded bars 2¾ in diameter which have been carbonised and graphitised. The permeability of the product normal to the extrusion direction was 5×10^{-4} sq. cm per sec, about 50 times lower than a conventional low permeability graphite. The two processes described, which have been termed liquid and gas impregnation, may be combined to give maximum impermeability in depth.

SCALING UP FURFURYL PROCESS

Because of its comparative simplicity the furfuryl alcohol process was selected for a larger scale study to assess the possibilities of producing the fuel rods for the experimental high-temperature gas-cooled reactor to be built at Winfrith Heath, Dorset (Project Dragon). This work has been undertaken by the Hawker Siddeley Nuclear Power Company under contract to the UKAEA.

The prototype graphite fuel tubes for this reactor are approximately 6 ft long and 2·5 in diameter and it was shown that full-sized prototype fuel rods could be successfully produced using the furfuryl alcohol process. The illustration shows completed fuel rod sections the permeability of which have been reduced 10^4 times by the process.

Two problems met with during the course of the work are worthy of mention. The first was



Impermeable graphite sheaths for high-temparature reactor fuel elements.

associated with the instability of furan resins and in particular the increasing tendency with bulk of liquid towards a violent exothermic reaction leading to rapid formation of the solid polymer. Apart from minimising the volume of liquid used in impregnating fuel rods by adjusting the impregnation techniques, it has been found possible to overcome the instability by a suitable choice and careful control of the acid catalysts used to promote polymerisation. A second problem which arose was concerned with quality variations in the graphite which was being used for the manufacture of the fuel rods. After a large number of specimens had been processed it became apparent that there was a relationship between the initial gas permeability of the graphite and the response of the graphite to the impregnation process. Although it has been shown that such variations in initial permeability can be accommodated by the process it would be more desirable for the economy and reproducibility of the process to use a more sensitive quality control measurement. Determinations of the pore size distribution of various batches of graphite have indicated the possibility of using such a measurement as a basis for the selection of graphite appropriate for impregnation.

An interesting yet troublesome feature during this impregnation work has been the determination of permeability coefficients of the impregnated material particularly at permeability levels better than 10^{-6} sq. cm per sec. A vacuum leak-test was found to be necessary as other methods such as pressure decay were notably insensitive at these low permeability levels. For fuel rods which have a uniform permeability coefficient of 10^{-9} sq. cm per sec, however, the test period required to obtain a true coefficient by this method is approximately 2,000 hours.

Although this period could be considerably reduced by using low density, small molecular size gas such as helium as the diffusing medium, it would be necessary to remove the gas entrapped in the pores of the graphite first. The total test period would therefore be lengthened instead of shortened by this method.

For many purposes it is only necessary to obtain an approximate value of the permeability coefficient for a certain thickness of tube wall. The observed behaviour of the gas movement through impregnated graphite of very low permeability is consistent with a diffusion mechanism so it is possible, using the basic diffusion law together with the conditions applicable to the present testing technique, to decide whether the component is within the specification without necessarily attaining equilibrium conditions during the testing period.

Although mass-flow permeability measurements are a useful indication of the quality of the material it is likely that the final testing of the fuel rods for the high temperature reactor will involve measurements which will give a direct indication of the time required for fission product gases to diffuse through the wall of the fuel tube.

Graphite is one of the few materials which increases in strength with temperature (the strength at 2,500° C is approximately double the room temperature strength) and this, coupled with the retention of low permeability at elevated temperatures exhibited by this new material indicates an increasing field of specialised application in the general metallurgical and chemical engineering industries.

As part of the current programme on impregnated graphite a small production unit is to be installed by Hawker Siddeley with an ultimate throughput of a few hundred tons of impregnated graphite a year. It is anticipated that this plant will be operational by mid 1960.

Acknowledgements

The following participated fully in the work on impermeable graphite at the Royal Aircraft Establishment and are co-patentees in the relevant patents—A. R. G. Brown, W. Johnson and G. Hughes.

J. G. Campbell and D. R. Perels were co-workers on this project at Hawker Siddeley and thanks are due to Mr. G. J. Metcalfe, chief metallurgist for his enthusiastic support throughout this work.

The authors wish to thank Mr. R. A. U. Huddle, formerly of the HTGCR Division, AERE, and now head of materials branch Dragon project, for his interest and encouragement in this work.

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Plain Words

By Capricorn

If only one could escape from day-to-day routine—just to step back and see things from a distance. But each day brings a new flood of tasks, decisions to be made, questions to answer, papers to scan, so that the very means of making these decisions, answering these questions, withers for want of nourishment. This, it seems to me, is one of the central problems of our time: how do we revive those useful minds that have become habitual in their duties? Men in higher management, experienced, skilled and practised in their art, need refreshment as much as schoolboys, and may gain more from it.

Recognising this shortcoming of our social system, Associated Industrial Consultants have introduced an unusually well conceived series of short management courses. At Dunford College they teach management, but with a difference. Senior men of 40 to 50, particularly from small and medium concerns, are those calculated to benefit most from the AIC courses.

But such men are not easily spared from the daily running of their businesses. How is this difficulty to be overcome? I gather that the courses are offered to firms not individuals. The onus is then on the firm to select a man for the course and not on the man to get leave of absence. It is the firm, not the individual alone, which is intended to profit from this training. AIC propose to interview not only course members but their principals, so that by familiarity with the working of a company and its problems, the staff of the college can best ensure constructive advantages to that company. At the same time appreciation courses will be conducted for the trainee's colleagues, so that they will be more sympathetic to his new ideas and ready to accept them.

The course lasts three weeks but after two the student goes back to his company for a week, where he can deal with the problems that have arisen in his absence, and also investigate the implementation of techniques he has learned. On returning to the college he will be expected to present a reasoned case for introducing a new project in his own firm. Subsequently AIC representatives will carry out follow-up " service " visits to the company to assist and advise in putting the new principles into practice.

At least it's a good start. But I should like to see a situation in which there are two men to every job—when the promise of automation has been fulfilled. Then six months of every year can be spent in further education, with a holiday or two thrown in. Senior executives, especially, are in need of such an opportunity, and the country is in need of good executives. Lord Derby once reproached his jockey: " You could have won that race."

" What," replied the jockey, " without the horse ? " Neither can we win the industrial race without sufficient jockeys.

Letters to the Editor

The Aircraft Industry

SIR, I was very interested to read again your prophetic Plain Words of 21 September, 1956, at this moment, three years later, when I am leaving the aircraft industry and the country.

All power in aviation has indeed now been " deposited with the State " and far more serious consequences than that of my departure will result.

The existence of an independent industry has been an essential factor in the formulation of policy. Repeatedly, in the 30 years I have known it, the industry has by its experience and the courage of its pioneers put forward and backed important new ideas and, equally important, prevented ghastly blunders. These easily arise from the fact that official decisions rest, in ascending scale, in the hands of politicians, technical and Service experts and administrative civil servants. It is no secret that the first are given to follow expediency, the second are generally lacking in practical experience of the possibilities and limitations of aircraft development, particularly of its time scale, while many of the third are imbued mainly with their own importance notwithstanding a complete lack of any industrial and management experience.

It would be surprising, therefore, if the resultant policies could dispense with a strong and critical opposition—and indeed they cannot.

It is no use pretending that a Government dominated industry consisting of two large groups will be in any position to take an objective view of the country's best interests. Each will be too concerned with survival and in countering the political pressures of its rival. Both, for instance, are competing strenuously for the supersonic transport project which in my opinion, and I am not alone, is beyond the economic and technical scope of this country as well as being an extremely dubious commercial proposition. Certainly it will be a very poor provider of employment (except for technicians!).

The management problems, already very great in an industry in which every new aircraft development is a ten year adventure of faith requiring superb leadership, will be beyond the power of any man, however able, in the new giant set-ups, especially with the intensified official interference and control already apparent.

Brought about by dishonest means, this much vaunted rationalisation will lead to bad ends; it will be followed by a rapid decline, much greater than necessary, in the industry's employment and international standing.

Yours truly,
W. E. W. PETTER.

Curdridge,
Nr. Southampton.
16 January, 1960.

Editor's Note : The ENGINEERING Plain Words to which Mr. Petter refers had this to say in connection with his development of the Gnat light jet fighter : " No country can afford to leave the development of its military aircraft wholly to private ventures, but Mr. Petter's remarkable experiment shows the vital necessity of permitting some freedom of action to the men who have exceptional abilities. If, by some twist of politics, we ever deposit all power and authority in the State, it will be goodbye to the Petters of the engineering world."

Editorial comment appears on page 109 of this issue.

Fuel Consumption in Cars

SIR, Your review of *The Autocar Road Tests, Spring 1959* (ENGNG., 16 Oct. '59, p. 353) and the interest shown in the analysis of fuel consumption by the subsequent correspondence in your pages prompt me to report some experiments related to this.

In experiments carried out both here and in England, I had found that with a warm engine specific fuel consumption was substantially the same for both highway driving and city traffic (excluding rush-hour conditions). This is not unreasonable. Traffic driving increases consumption above that for steady driving at the same speed; highway driving, while steadier, is at a higher average speed to which a higher consumption is appropriate. It is quite possible that the mean specific consumption is much the same under both circumstances, especially for the driving conditions in this country.

This led me to wonder if the apparently higher consumption in local driving was due primarily to more frequent cold starts, each of which involves an increased consumption of fuel during the warming-up period.

Accordingly, I performed a series of tests with a 1956 Plymouth, this having a six-cylinder side-valve engine with a single carburettor and an automatic choke. Immediately before the tests, the ignition system and choke were overhauled, and remained unaltered through the tests. The tests were made between 29 November, 1959, and 3 January, 1960, covering 2,031 miles, and results were obtained for cold starts-per-mile from 0·0066 to 0·12. By good fortune, the ambient temperature was relatively constant throughout the tests. According to the hypothesis of invariant " warm " fuel consumption, the results should correlate in the form:

$$\frac{1}{(\text{m.p.g.})_{\text{actual}}} = \frac{1}{(\text{m.p.g.})_{\text{warm}}} + \left(\frac{\text{gallons}}{\text{start}}\right)\left(\frac{\text{starts}}{\text{mile}}\right)$$

When the resuts were plotted, it was seen there was considerable regularity: the (United States) gallons-per-start was found to be 0·243, and the m.p.g. (warm) to be 20·4. The standard dispersion of the results was only 3 per cent.

An automatic choke may well be a wasteful device; however, the regularity of warming-up performance which it gives was important to the success of this experiment. While the results apply strictly to one car and one driver, their regularity lends considerable weight to the hypothesis advanced. The results also show the importance of a rapid warm-up for overall fuel economy.

Yours faithfully,
P. D. RICHARDSON.

Division of Engineering, Brown University,
Providence, Rhode Island, USA.
6 January, 1960.

Decimal Aberration

SIR, Printers' errors show the " human side " of printing. I like ENGINEERING for many reasons and for this kind of humanity too.

You published an excellent report on the new MAN diesels for supertankers (ENGNG., 11 Dec. '59, p. 622) but the staff of the MAN Diesel Department was amused by the remark that the really " quite satisfactory " fuel consumption was no more than 0·033 lb per b.h.p. hour, instead of 0·33!

Faithfully yours,
FRITZ RUEF.

9 Bismarckstrasse,
Augsburg, Germany.
3 January, 1960.

Editor's Note: It was we, not the printers, who erred.

Events in Advance

German Trade Fairs

Cologne has become well established as a German centre for the holding of exhibitions and trade fairs. Several are due to take place there this year: the earliest such event being the five-day International Furniture Fair, which will open in three weeks' time. The International Spring Fair for Household Goods and Hardware will follow in mid-March. This latter exhibition is open only to the trade and

usually attracts some 60,000 buyers from all parts of the world.

Among the many categories of goods on exhibition will be electrical appliances, heating and cooking equipment, washing machines, metal fittings and fixtures, cleaning and polishing requisites, cutlery, tools, brushes and brooms. British goods will be represented by displays organised with the collaboration of the Board of Trade. A three-day International Autumn Fair for Household Goods and Hardware will be held, on the same lines as the spring fair, from 9 to 11 September. The United Kingdom agent for all three events is Mr. Neven du Mont, 18 Queensberry Place, London, SW7.

This year's German Industries Fair will take place in Hanover, will open on 24 April, and is widely recognised as a leading international event in Western Europe for the display of capital goods, although a certain number of consumer goods, such as cutlery, hardware and jewellery, are also shown. Last year's fair covered an area of some half-a-million square yards and attracted about 4,600 exhibitors, of whom more than 700 came from abroad; no fewer than 25 foreign countries being represented in this way. It is understood that exhibition space will not be increased for this year's fair, except in the case of the halls set apart for the displaying of precision instruments and optical goods and building and building materials. Schenkers Limited, Royal London House, 13 Finsbury Square, London, EC2, are the United Kingdom agents for this fair.

Exhibitions and Conferences

Hotel and Catering Exhibition, International.—Now current and will end on 28 Jan., at Olympia, London, W14. Organised by the Hotel and Catering Exhibition (London) Ltd., 623 Grand Buildings, Trafalgar Square, London, WC2. Tel. WHItehall 1371.

Furniture Exhibition, 11th.—Mon., 25 Jan., to Sat., 6 Feb., at Earl's Court, London, SW5. Sponsored by *The Daily Express*. Organised by F. W. Bridges and Sons, Ltd., 641 Grand Buildings, Trafalgar Square, London, WC2. Tel. WHItehall 0568.

Cologne International Furniture Fair.—Thurs., 11 Feb., to Mon., 15 Feb., at Cologne. Agent: Mr. Neven du Mont, 18 Queensberry Place, South Kensington, London, SW7. Tel. KENsington 6593.

Pilot Plants in Metallurgical Research and Development, Symposium.—Mon., 15 Feb., to Thurs., 18 Feb., at Jamshedpur, India. Organised by the National Metallurgical Laboratory, Jamshedpur 7, India.

Cologne Household Goods and Hardware Fair.—Fri., 11 Mar., to Mon., 14 Mar., at the Fair Grounds, Cologne. Agent: Mr. Neven du Mont, 18 Queensberry Place, South Kensington, London, SW7. Tel. KENsington 6593.

Inventors' Exhibition, Ninth International.—Fri., 11 Mar., to Sun., 20 Mar., at Brussels. Apply to the Institute of Patentees and Inventors, 207 Abbey House, Victoria Street, London, SW1. Tel. ABBey 1616.

Osaka International Trade Fair, Fourth.—Sat., 9 April, to Tues., 26 April, in Osaka. Offices: Honmachi-bashi Hiagashi-ku, Osaka, Japan.

Lille International Trade Fair.—Sat., 23 April, to Sun., 8 May, at Lille. Agents: Weigel, Leygonie and Co., Ltd., 31-32 King Street, London, WC2. Tel. TEMple Bar 4825.

German Industries Fair, Hanover.—Sun., 24 April, to Tues., 3 May, at Hanover. Agents: Schenkers Ltd., Royal London House, 13 Finsbury Square, London, EC2. Tel. METropolitan 9711.

Graz International Spring Fair.—Sat., 30 April, to Sun., 8 May, at Graz, Austria. Apply to the British-Austrian Chamber of Commerce, 29 Dorset Square, London, NW1. Tel. PADdington 7646.

Brussels International Industries Fair, 33rd.—Sat., 30 April, to Wed., 11 May, at Brussels. Apply to Belgian Railways, 167 Regent Street, London, W1. Tel. REGent 1491.

Zagreb International Spring Fair.—Sat., 30 April, to Sun., 15 May, at Zagreb. Agents: Auger and Turner Group Ltd., 37-38 Margaret Street, Cavendish Square, London, W1. Tel. MAYfair 3283.

Valencia Samples Fair, 38th International.—Sun., 1 May, to Sun., 15 May, at Valencia. Organised by the Feria Muestrario Internacional de Valencia, 2 Llano del Real, Valencia.

Cologne Household Goods and Hardware Fair.—Fri., 9 Sept., to Sun. 11 Sept., at Cologne. Agent: Mr. Neven du Mont, 18 Queensberry Place, London, SW7. Tel. KENsington 6593.

Meetings and Papers

Association of Supervising Electrical Engineers

CROYDON
"Work of the Royal Mint Refineries," by J. T. McEvoy. South London Branch. Greyhound Hotel, High Street, Croydon. Thurs., 28 Jan., 8 p.m.

Birmingham Exchange and Engineering Centre

BIRMINGHAM
"Nuclear-Powered Submarines," by Commander E. A. Woodward, R.N. (retd). Wed., 27 Jan., 6.30 p.m. (Admission by ticket.)

British Institution of Radio Engineers

LONDON
"Training for Operating and Maintaining Television Broadcasting Equipment," by Dr. K. R. Sturley and A. E. Robertson. London School of Hygiene and Tropical Medicine, Keppel Street, WC1. Wed., 27 Jan., 6.30 p.m.*

Combustion Engineering Association

EDINBURGH
"Utilisation of Waste Products as Fuel": Discussion opened by H. A. Mercer, at 10.30 a.m.* Discussion on "Fuel Saving Schemes," opened by R. Bunting, at 2 p.m. Royal British Hotel, Princes Street, Edinburgh. Wed., 27 Jan.

Illuminating Engineering Society

BIRMINGHAM
"Domestic Lighting," by D. W. Durrant. Birmingham Centre. YMCA, Snow Hill, Birmingham. Mon., 25 Jan., 6 p.m.

LEICESTER
"Recent Developments in Light Sources," by D. H. Holloway. Leicester Centre. Offices of the East Midlands Electricity Board, Charles Street, Leicester. Mon., 25 Jan., 7 p.m.

Institute of Fuel

LIVERPOOL
"Fire Prevention in the Petroleum Industry," by E. P. Lancashire. Merseyside Subsection. Liverpool Engineering Society, 9 The Temple, 24 Dale Street, Liverpool. Wed., 27 Jan., 6 p.m.

NOTTINGHAM
"Education and Training of Fuel Technologists," by Dr. D. T. A. Townend. East Midland Section. Nottingham and District Technical College, Nottingham. Thurs., 28 Jan., 6.30 p.m.

Institute of Marine Engineers and Royal Institution of Naval Architects

LONDON
"Control and Instrumentation of Marine Reactors," by R. Anscomb and F. Hutber. Institute of Marine Engineers, 76 Mark Lane, EC3. Tues., 26 Jan., 5.30 p.m.*

Institute of Sheet Metal Engineering

WOLVERHAMPTON
"High Speed Blanking and Piercing and the Production of Laminations," by N. V. Larking. Wolverhampton Section. Wolverhampton and Staffordshire College of Technology, Wulfruna Street, Wolverhampton. Wed., 27 Jan., 6.45 p.m.

Institute of Welding

CHATHAM
"New Welding Processes." Demonstration. Medway Section. Medway College of Technology, Chatham. Wed., 27 Jan., 2 p.m. and 6.30 p.m.

Institution of Chemical Engineers

MANCHESTER
"Rotating Band and Spinning Band High Vaccum Distillation." Discussion. North Western Branch. Manchester College of Science and Technology, Jackson Street, Manchester. Tues., 26 Jan., 6.30 p.m.

Institution of Civil Engineers

LONDON
"Planning and Design of Maintenance Bases for Civil Aircraft," by E. O. Measor, L. B. Haley and A. J. Harris. Tues., 26 Jan., 5.30 p.m.*

Institution of Electrical Engineers

LONDON
"Oral Presentation of Scientific Material," by Dr. A. Clow. Electronics and Communications Section. Wed., 27 Jan., 5.30 p.m.*
"Radio Communications by Means of Satellites," by Dr. A. W. Lines. Thurs., 28 Jan., 5.30 p.m.*
"Beam-Type Parametric Amplifiers: Some Aspects of Design and Use," by R. B. Dyott and C. R. Russell. Electronics and Communications Section. Fri., 29 Jan., 5.30 p.m.*
"Transistors in Switching Circuits," by M. Paskins. London Graduate and Student Section. Mon., 25 Jan., 6.30 p.m.*

NEWCASTLE UPON TYNE
"Field Suppression of Turbo-Alternators," by J. R. Hill, A. Hunt, W. J. Joyce and D. H. Tompsett. North Eastern Centre. Neville Hall, Westgate Road, Newcastle upon Tyne. Mon., 25 Jan., 6.15 p.m.

NOTTINGHAM
"Direct-Current Winder Drives Using Mercury-Arc Rectifier/Inverters," by L. Abram, J. P. McBreen and J. Sherlock. East Midland Centre. College of Arts and Crafts, Waverley Street, Nottingham. Wed., 27 Jan., 6.30 p.m.*

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"Some Aspects of Marine Reactor Safety," by K. Maddocks. Tues., 26 Jan., 6.30 p.m.

Institution of Heating and Ventilating Engineers

MANCHESTER
"Designers All: Engineer-Architect Collaboration," by G. Grenfell Baines. Manchester Branch. Engineers' Club, Albert Square, Manchester. Fri., 29 Jan., 6.30 p.m.

Institution of Mechanical Engineers

LONDON
"Problems of Maintaining Silence in Passenger Cars." Discussion. Automobile Division. Tues., 26 Jan., 6 p.m.*
"Technical and Economic Aspects Covering the Ocean Transportation of Liquid Methane," by Dr. J. J. McMullen. Thomas Lowe Gray Lecture. Wed., 27 Jan., 6 p.m.*

Institution of Plant Engineers

LIVERPOOL
"Steam Supplies from a Central Back-Pressure Plan to an Integrated Group of Factories," by J. B. Lancaster. Merseyside and North Wales Branch. Donnan Laboratories, The University, Liverpool. Thurs., 28 Jan., 7 p.m.

SHEFFIELD
"Instrumentation," by Dr. R. H. Baulk. Sheffield Branch. Grand Hotel, Sheffield. Thurs., 28 Jan., 7.30 p.m.

Institution of Production Engineers

BRIGHTON
"Sintered Oxide Cutting Materials," by R. N. Cook. Old Ship Hotel, Brighton. Wed., 27 Jan., 7 p.m.

MANCHESTER
"Practical Applications of Operational Research," by A. J. R. Veale. Manchester College of Science and Technology, Sackville Street, Manchester. Mon., 25 Jan., 7.15 p.m.

Institution of the Rubber Industry

MANCHESTER
"Developments in the Preservation and Testing of Latex," by M. W. Philpott. Manchester Section. Newton Heath Technical College, Manchester. Mon., 25 Jan., 6 p.m.

Institution of Structural Engineers

LONDON
"The Structural Engineer in the Field of Atomic Energy" by T. C. Waters. Thurs., 28 Jan., 6 p.m.*

Junior Institution of Engineers

LONDON
"Ceramics," by A. Dinsdale. Fri., 29 Jan., 7 p.m.*

Manchester Association of Engineers

MANCHESTER
"Development and Application of Lightweight Sandwich Structures," by H. R. Ashley. Engineers' Club, Albert Square, Manchester. Fri., 29 Jan., 6.45 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE UPON TYNE
"Fretting Corrosion," by A. J. Fenner and J. E. Field. Neville Hall, Westgate Road, Newcastle upon Tyne. Fri., 29 Jan., 6.15 p.m.

Operational Research Society

LONDON
"Operational Problems with Several Variables to Optimise," by Dr. B. O. Koopman. Royal Society of Arts, John Adam Street, Adelphi, WC2. Fri., 29 Jan., 6 p.m.*

Royal Aeronautical Society

LONDON
"Engineering Aspects in Man-Powered Flight," by B. S. Shenstone. Man Powered Aircraft Group. Fri., 29 Jan., 7 p.m.

Royal Society of Arts

LONDON
"Irrigation and Population in Pakistan, India and Ceylon," by Dr. R. Maclagan Gorrie. Tues., 26 Jan., 5.15 p.m.*

Sheffield Metallurgical Association

SHEFFIELD
"Analytical Chemistry of the Platinum Metals," by E. Jackson. BISRA Laboratories, Hoyle Street, Sheffield. Tues., 26 Jan., 7 p.m.

Society of Instrument Technology

LONDON
"Flame Failure Detection." Symposium. 26 Portland Place, W1. Tues., 26 Jan., 7 p.m.*

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. An asterisk (*) is placed where it is understood that refreshments are available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, WC1. (LANgham 5927)
Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham 2. (Midland 1914)
British Institution of Radio Engineers, 9 Bedford Square, London, WC1. (MUSeum 1901)
Combustion Engineering Association, 70 Jermyn Street, St. James's, London, SW1. (WHItehall 5536)
Illuminating Engineering Society, 32 Victoria Street, London, SW1. (ABBey 5215)
Institute of Fuel, 18 Devonshire Street, Portland Place, London, W1. (LANgham 7124)
Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London, EC3. (ROYal 8493)
Institute of Sheet Metal Engineering, John Adam House, John Adam Street, Adelphi, London, WC2. (TRAfalgar 6171)
Institute of Welding, 54 Princes Gate, Exhibition Road, London, SW7. (KNIghtsbridge 8556)
Institution of Chemical Engineers, 16 Belgrave Square, London, SW1. (BELgravia 3647)
Institution of Civil Engineers, Great George Street, London, SW1. (WHItehall 4577)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC2. (COVent Garden 1871)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C2. (Central 5181)
Institution of Heating and Ventilating Engineers, 49 Cadogan Square, London, SW1. (SLOane 3158)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, SW1. (WHItehall 7476)
Institution of Plant Engineers, 2 Grosvenor Gardens, London, SW1. (SLOane 0469)
Institution of Production Engineers, 10 Chesterfield Street, London, W1. (GROsvenor 5254)
Institution of the Rubber Industry, 4 Kensington Palace Gardens, London, W8. (BAYswater 9101)
Institution of Structural Engineers, 11 Upper Belgrave Street, London, SW1. (SLOane 7128)
Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, SW1. (VICtoria 0786)
Manchester Association of Engineers, 40 Brazennose Street, Manchester, 2. (Deansgate 2140)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle upon Tyne 1. (Newcastle 20289)
Operational Research Society, 64 Cannon Street, London, EC4. (CITy 1800)
Royal Aeronautical Society, 4 Hamilton Place, London, W1. (GROsvenor 3515)
Royal Institution of Naval Architects, 10 Upper Belgrave Street, London, SW1. (SLOane 4622)
Royal Society of Arts, John Adam Street, Adelphi, London, WC2. (TRAfalgar 2366)
Sheffield Metallurgical Association, 64 Crescent Road, Sheffield 7. (Sheffield 52865)
Society of Instrument Technology, 20 Queen Anne Street, London, W1. (LANgham 4251)

Modernising an 1875 Bridge

Many railway bridges built in the 19th Century are reaching the end of their working life. Replacement has to be carried through with minimum interference to traffic.

The bridge carrying British Railways' Western Region main line from Oxford to Worcester over the River Avon near Evesham was reconstructed in 1959; the finished bridge is shown in Fig. 1. As built in 1875—an even older bridge on the site dated from 1852—this bridge consisted of four wrought iron plate girder deck spans (two of 36 ft and two of 54 ft), decked overall in timber, and supported on masonry abutments at the banks and on three rows of cast iron screw piles driven into the river bed. Settlement of some of the screw piles had led to a rebuilding in masonry and brick of the central row in 1919. The structure as it was just prior to reconstruction last year may be judged from Fig. 2, taken during the work when the down-side girders were dismantled and while a new capping beam for the pier was being put into place. The bridge is built slightly on the skew.

Reconstruction was undertaken because working stresses had become high in the wrought iron girders and the difference in deflections under the loaded and unloaded spans, accentuated by a crossover on the bridge, had led to trouble with the transverse timber decking, which could not be made watertight. When the timber decking reached the end of its life, it was decided to reconstruct the whole of the superstructure, at the same time reducing the number of spans from four to two so that the remaining rows of screw piles could be eliminated. As now completed the bridge has one span of 98 ft and the other of 90 ft.

The new spans follow standard modern practice, and consist of two welded plate girders for each track with precast reinforced concrete well-deck units resting on concrete pads cast in short lengths and dowelled to the top flanges, best seen in Fig. 3. The permanent way is standard with cross sleepers on 6 in of ballast and the crossover has been re-sited clear of the bridge. The twin girders under each track are fully braced laterally between the top flanges and also have adequate sway bracings, but there is no connection with the girders under the adjacent track. At the central pier, particular care has been taken to centralise the reactions, the main girders "oversailing" one another, piggy-back fashion. Welded mild steel knuckle pin bearings have been used on the pier and so fixed as to give uninterrupted support to the concrete deck. Bronze slipper plate sliding bearings are provided at the abutments. The joints between the concrete deck units have been sealed and made watertight.

At first the tracks were "interlaced" over the up-line spans and the engineers given complete occupation of the down-line spans, the position being reversed after that half of the bridge had been dealt with. This arrangement had a direct bearing on the strengthening of the central pier. As constructed in 1919, the centre of the masonry was pierced by a 10 ft wide arch and above the 2 ft thick soffit rings there was then ample depth to accommodate the 4 ft 6 in deep girders of the original spans. But the new girders are 7 ft 6 in deep, and it would have been difficult to fish-belly these girders and at the same time retain the single centrally placed bearings on the pier. The masonry had therefore to be cut down below the level at which the reactions could be properly dispersed without overloading the arch and the pier has been strengthened with a new prestressed concrete capping beam, precast and erected in two halves with a gap of 2 in between the two parts. The beam was subsequently prestressed with a load of 3,192 tons. Each part of the capping beam weighed 30 tons, and was reinforced to carry the reactions from single-line loading prior to prestressing. During erection of the beam and prior to prestressing, the arched part of the pier was protected by hardwood packing under the beam and the arch was temporarily propped and strutted.

This temporary strutting in the arch of the pier consisted of military trestling as shown in Fig. 4, four struts being provided in the first stage.

This arrangement was necessary as the arch became very unevenly loaded under traffic and crane working, especially after the pier had been cut down almost to the arch ring to allow the first half of the capping beam to be placed. In these circumstances, the arch, which was already cracked through the crown, was assumed not to be effective and to provide nothing towards the strength of the bridge.

After the new down-line superstructure had been erected, however, the struts had to be reversed and doubled to take the thrust of the increased loads imposed on the pier following the reduction of the spans from four to two.

The concrete for the capping beam was specified to have a cube strength of not less than

Fig. 1 The completed two-span bridge.

Fig. 2 (left) Placing the down-line section of the capping beam on the pier. The beam not only strengthened the head of the pier but provides a bedcourse for the new long-span girders. The original screw piles of the intermediate piers, which have now been eliminated, and the form of the old four-span construction, are exposed by the partial dismantling of the bridge and can be seen in the photograph. The temporary strutting in the arch of the pier can also be seen.

Fig. 3 (right) The well-deck units and bedding pads. There is ample space between the underside of the concrete and the bracing to permit painting and maintenance.

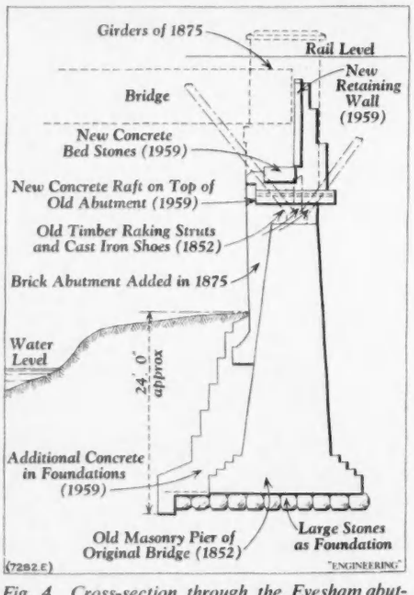
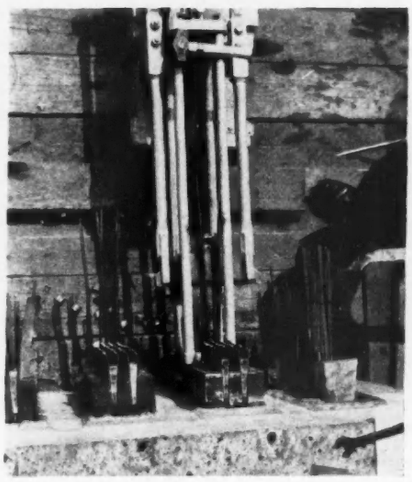

Girders of 1875
Rail Level
New Retaining Wall (1959)
Bridge
New Concrete Bed Stones (1959)
New Concrete Raft on Top of Old Abutment (1959)
Old Timber Raking Struts and Cast Iron Shoes (1852)
Brick Abutment Added in 1875
Water Level
24' 0" approx
Additional Concrete in Foundations (1959)
Old Masonry Pier of Original Bridge (1852)
Large Stones as Foundation
(7282.E)
"ENGINEERING"

Fig. 4 Cross-section through the Evesham abutment showing how it was added to in earlier works and then finally strengthened during 1959.

8,000 lb per sq. in at 28 days, and tests showed that this figure was exceeded. The Magnal-Blaton system of prestressing was used, the 14 bundles each of sixty-four 0·276 in diameter wires (110 tons per sq. in) being threated through ducts 8½ in by 3 in. Three jacks were used at a time, the wires being stressed in pairs in a specified order from one end only. A dry rich concrete of 1 : 1 : 1½ with a water/cement ratio of 0·25, mixed in a pan type mixer, was rammed in the 2 in gap between the two halves. Finally, after prestressing, cement grout was forced at a pressure of 30 lb per sq. in into the ducts, and the wedges and sandwich plates encased in 6 in of concrete covering the ends of the beam. The prestressing as carried out without occupation, stressing of the cables being done only between trains; this work is shown in progress in Fig. 6. The centre of the prestressing force was 5 in below the centroid of the capping beam which, after the stressing, had a camber of about $\frac{1}{16}$ in. Withdrawal of the timber packings completed the successful transfer of the load from the arched portion of the pier.

Since the spans were reduced from four to two, extra weight was imposed on the two abutments, and considerable work had to be carried out in strengthening both of them to meet the new requirements, as shown in the cross-section of the Evesham abutment, Fig. 5. This drawing shows the typical piecemeal construction that is to be found with many of the older railway bridges.

Fig. 6 View (from above) of the ends of the prestressing wires in the pier capping beam, showing one pair being stressed.



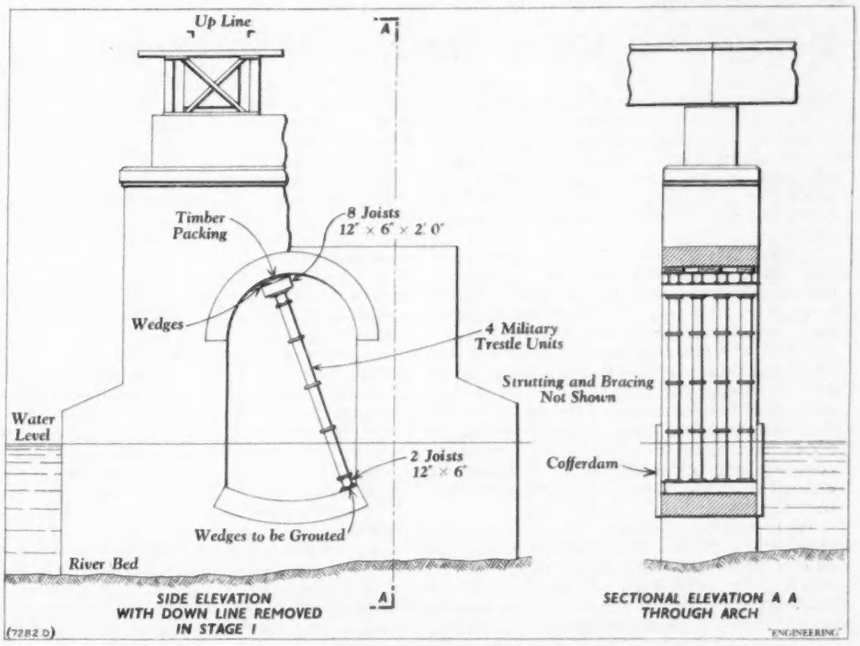


Fig. 5 Temporary strengthening of the central pier, using military trestling.

The even earlier bridge built in 1852 had masonry abutments and a timber superstructure, and was founded on large stones at about 24 ft below ground level. In 1875 a brick headwall was added to each abutment to raise the height of the original masonry. Subsequently the added brickwork became cracked and moved out of plumb, so during last year's work the top was demolished and a concrete raft laid over the top of the old masonry, with new bedstones and a retaining wall of brick-faced concrete built to accommodate the new girders. To provide additional support to the old foundations of the brickwork added in 1875, a new concrete foundation, reinforced with old rails and taken down to the bottom of the old masonry abutment, was also added.

On the Worcester side of the river, the abutment was strengthened in a similar manner, but the original foundations were not so deep as on the Evesham side.

The main girders were erected one at a time, plumbed and aligned with the aid of parallel drifts in the lateral and sway bracings. The connections were completed with $\frac{7}{8}$ in high-strength bolts (45/55 tons per sq. in ultimate) tightened to a torque of 390 lb-ft. There was, of course neither riveting nor welding on site; moreover, the surface of the steelwork had been prepared by pickling (to remove all millscale) and painted with two priming coats (red lead and red and white lead respectively) as well as with the under and final coats of micaceous iron ore paint. These coats were all applied in the shop before delivery, so that the amount of work on site was kept to a minimum. The contact surfaces of the parts joined with the high-strength bolts were not painted.

The bridge was designed in the Steelwork Office at Paddington to the approval of Mr. M. G. R. Smith, the chief civil engineer of the Region.

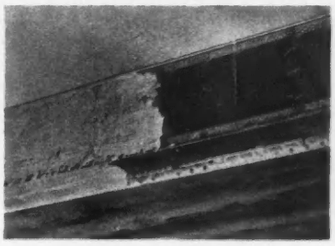
The girderwork, which weighs 107 tons, was fabricated by the Fairfield Shipbuilding and Engineering Company Limited, of Chepstow, who also cast the concrete pads on the top flanges of the main girders. The reinforced concrete bedcourse units were cast by the Concrete Development Company Limited at their works at Iver, and this firm also carried out the prestressing on site. The reinforced concrete welldeck units were cast in the Taunton Concrete Works of the Western Region, and the erection on site was carried out by railway labour under the direction of Mr. A. W. McMurdo, district engineer, Wolverhampton.

Fire Protection for Steelwork

A revolution in structural steelwork for buildings is promised by the introduction of a lightweight fire protection. Hitherto, bylaws and standards have required such steelwork used to be encased in concrete to provide it with some degree of fire resistance. This was a major factor contributing to the higher cost of steelwork with respect to reinforced concrete. The possibilities of lightweight protection have been recognised for some years and, elsewhere, particularly North America, such casings have already come into regular use.

A determined effort is now to be made to put a lightweight vermiculite plaster on to the British market. As shown in the illustration, beams and girders are wrapped with expanded metal which acts as a supporter for the plaster. Tests conducted by the Fire Research Station show that the protection given by such a plaster is adequate to satisfy all bylaws. The weight of a vermiculite plaster is only 40 lb per cu. ft.

The advantages are several fold. In the first place the dead load of the structure is reduced, so allowing the beams and columns to be smaller, and therefor lighter; this in turn leads to smaller foundations. As the illustration shows, a hollow space is obtained between the casing and the steelwork, and this space can well be used as ducting for services. The plaster is ready for final decoration and requires no rendering; indeed, advantage can be taken of its pleasant colouring to provide the finish. The number of tradesmen required on the job is reduced and so is the amount of equipment; most important of all, formwork and shuttering are eliminated. And for the near future even greater improvements are promised by the mechanisation of plastering—equipment will soon be commonplace for "gunning" the plaster on to the steelwork.



Metal lathing round the steel joist or column provides the base for vermiculite plaster.

A statement of the advantages is contained in a report that has been prepared by Frederick S. Snow and Partners, the London consulting engineers. The report has been sponsored by a consortium that includes the British Constructional Steelwork Association, the Expanded Metal Company, the Gotham Group, and Mandoval Limited (as suppliers of the Vermiculite). Copies can be obtained from Room 1, Fifth Floor, Windsor House, Kingsway, London, WC2 (10*s* 6*d*). Included in the report are diagrams and photographs showing how the structural details should be designed.

Designing Cars for the Motorways

By Gordon Wilkins

The opening of Britain's first motorway produced a spectacle which is already familiar from experience in other countries: hundreds of vehicles stopped with mechanical troubles and tyre failures. It happened in Germany over twenty-five years ago when the first *autobahnen* were opened and it has happened in other countries since.

The fact that it could still happen here now is not however an indication that British manufacturers have learned nothing from the experience of others. Rather does it reflect the fact that we have a higher proportion of old vehicles in use than any other leading industrial country. This is partly due to purchase tax which puts a brake on market expansion and prevents replacement of old vehicles, and partly due to the fact that our ratio of cars to population was already higher than those of other leading European countries and there was therefore less scope for expansion by the sale of new vehicles to new owners.

We have come a long way since the days when even Bentley Motors were obliged to warn their owners against maintaining too high a cruising speed on the *autobahnen*. Although the British road system has not permitted high cruising speeds, export markets have given manufacturers plenty of experience. Years ago the BMC checked the efficiency of the new bearings adopted for their A and B type engines by running a fleet of cars for 60,000 miles on the German motorways at an average speed of 60 m.p.h. and they have just demonstrated the capabilities of a new 2 ton truck with a run up the London to Birmingham motorway (M1) at an average speed of 63·7 m.p.h. with full load.

There is, however, some evidence to show that British designers are still running their engines at higher revolutions than their Continental competitors, and this appears to be reflected in higher fuel consumptions at motorway cruising speeds. Take, for example, two comparable small cars, the Renault Dauphine and the Triumph Herald. The French car is geared to run at 14·8 m.p.h. per 1,000 r.p.m. in top, whereas the British model runs at only 13·25 m.p.h., though it has a larger engine and four speeds instead of three. As given by *The Motor* and *The Autocar* in their road tests, the steady speed fuel consumptions at 40 m.p.h. are for the Dauphine and Herald respectively 52·6 and 44 m.p.g., and at 60 m.p.h. the figures are 40·4 and 33 m.p.g. The fact that the Renault shows only a 23 per cent loss in miles per gallon with the increase in speed against 25 per cent by the Triumph may also reflect the differences in the shape of the two cars.

Turning to the 1½ litre class it is found that the Peugeot 403, geared to do 17·3 m.p.h. per 1,000 r.p.m., shows a small advantage in fuel consumption throughout the range when compared with the Wolseley 15/60 which, like the Austin A55 and Morris Oxford, is geared to do 15·6 m.p.h. In this case there does not seem to be much to choose between the two body shapes on the score of drag, except that the Wolseley has hoods over the headlamps which probably exact a measurable penalty at the maximum speed.

The availability of an excellent electrically controlled overdrive which permits full torque changes has solved this problem on the more expensive cars but as motorway driving becomes a more familiar feature of British motoring it is to be hoped that it will encourage designers to cease regarding first gear purely as an emergency ratio. First gear should be provided with synchromesh engagement as it is on many Continental small cars and the axle ratio selected to make top an economical cruising gear. No one has yet approached the 20 m.p.h. per 1,000 r.p.m. which is one of the secrets of the Volkswagen's success, but the total failure of automatic clutches on the home market is surely due to the British driver's willingness to change gear. The emphasis on top gear flexibility is clearly exacting a fairly high price in extra fuel consumption under motorway conditions.

The rapid rise in car performance is forcing the pace of tyre development. In cars with engines of 2½ litres and over, fast cruising on motorways has recently shown that we are now reaching a position familiar in the United States, where the tyres supplied as standard equipment on family models are not adequate for the full performance available even when inflated to the pressures recommended for motorway use. In some cases 15 minutes of running at sustained high cruising speeds (over 80 m.p.h.) is sufficient to generate destructive heat which then or soon afterwards produces a big blister on the tread or a general distortion of the whole tread band which causes violent vibration. Either the standard grade tyres should be improved or buyers should be given a much more precise indication of their limitations.

Special tyres have had to be designed. For the 220 Mercedes, nylon tyres have been developed by the German Dunlop company and their high heat resistance has enabled a more flexible carcase to be used, giving a more comfortable ride than the usual high-speed tyre.

Use of flexible walls in tyres, in conjunction with a tread stiffened by wire mesh or other means, to give very high cornering power, has spread since the Michelin X showed the way, and several such tyres are now available in Britain. Such tyres also have very good wear characteristics, but at least one highly publicised fatal accident on a car fitted with an experimental set of such tyres has served to emphasise that they must be used with discretion. They push the breakaway point so high that, when it is reached recovery may be beyond the capacity of the most highly skilled driver.

Another problem which has been thrown into prominence by M1 is that of stability at high speeds. This has been with us for a long time, but traffic conditions have usually prevented sustained high speeds even on open stretches where wind effects are greatest. It may, however, explain a number of otherwise inexplicable crashes involving single cars. Several bad accidents on M1 have shown that many drivers are quite unprepared for the effects of wind and have no conception of the forces involved. A valuable addition to the available data on the subject is the recent Motor Industries Research Association report for 1958-9 which contains, among other things, the results of tests carried out on an Austin A50 saloon and a Bentley S type saloon car in the 24 ft wind tunnel at the Royal Aircraft Establishment.

In side winds the lift increases much more rapidly than the drag and has an important effect on the pitching and rolling moments. Tests with the cars at an angle of yaw in the tunnel giving the equivalent of a 70 m.p.h. road speed in a 25 m.p.h. side wind showed that lift on the Austin was increased by 146 per cent—an extra 160 lb—and on the Bentley by 120 per cent—an extra 230 lb. Naturally this increase in lift is not symmetrically distributed. The side force generated on the front axle of the Austin was 135 lb and on the rear 45 lb in the above side wind condition. Forces for the Bentley in the same condition were 195 lb and 40 lb respectively.

In gusty conditions on roads with surfaces made slippery by rain, the magnitude of these forces is itself sufficient to explain sudden loss of control where the driver is inexperienced. And, of course, as the yaw increases, so do the sideways forces and yawing moments, tending to produce complete loss of control, which has already resulted in several cars turning over.

Swedish Sports Car Made in England

One of the exhibits at the Brussels Motor Show this week is the new Volvo P 1800 sports car in its finalised form. As the present capacity of the Volvo factory at Gothenburg is fully occupied, the unit body-chassis will be made in England by the Pressed Steel Company and then painted and trimmed by Jensen Motors of West Bromwich who now form part of the Norcross group. Mechanical parts to complete the car will be supplied from Sweden, but a fair proportion of the components are also British, including the twin SU carburettors, the disc front brakes and the optional Laycock de Normanville overdrive.

The engine is a new four-cylinder pushrod unit with the same stroke as the existing 1,582 c.c. unit but with larger bores (84·14 by 80 mm, 1,780 c.c.). It has a five-bearing crankshaft running in copper-lead bearings. The compression ratio is 9·5 to 1 and maximum power is 100 b.h.p. SAE at 5,500 r.p.m.

Transmission is through a four-speed all-synchromesh gearbox. Front suspension is conventional. At the rear coil springs are used with a rigid hypoid axle located by radius arms and a Panhard rod. American type dampers are used, with freon-filled nylon cells to prevent aeration of the fluid. A feature of the electrical equipment is a tamper-proof armoured cable between ignition switch and coil to defeat car thieves with wander leads. This was a feature of BMW cars for many years.

Human Element

Second Thoughts on Crowther

The first stimulus of the Crowther report's more than usually direc- proposals has faded. Some of the doubts of those in industry most concerned at the standards of boys coming up to school leaving age are now being heard.

And the doubts most reasonably entertained come from those who have for long past held exactly the same objectives to be desirable as did those who examined the problem with Sir Geoffrey Crowther. The common ground is that a better educated school leaver is wanted than is currently being turned out in this country.

Inevitably the major notice has fallen upon the Crowther proposal to lift to 16 the school leaving age, at least for the great majority. While this sounds like a reform, and certainly was the easiest way to attract attention, it is not on the face of it the most needed reform, or even a reform at all for the economically most important section of those at school.

It is a worn but widely accepted cliché that *those who can, do; those who can't, teach*. Nobody can be other than disturbed at the standard of science and mathematics teaching in the schools and while the numbers problem may not be too bad there is no suggestion that first class men or perhaps many second class, are preferring the schoolroom to the challenge of research and development, or the rewards of industry in general.

For the universities endlessly to toil with half prepared material sent up to them from sixth forms that lack contact with outstanding and lively teachers is a waste of everybody's time that will cost very dear in the long run.

The Russians are alleged to have a system whereby a proportion of their best science graduates are more or less drafted to teach for a period. This apparently applies to mathematics and engineering graduates as well.

There would be two definite advantages in this. First that some of the graduates would find themselves attracted to teaching and presumably stay. Second that the inevitable staleness of staff who have not been active in industry or back to the lecture room in many years would be signally stirred up.

There is obviously a retort that it takes some terms for a new teacher to become efficient. There is something in that but unfortunately for the holders of that particular opinion it is usually expressed as taking some time to "settle down." It is also accompanied by withdrawal from the intellectual turmoil and inquiry of undergraduate life.

The Crowther report has many good and valuable things in it. Educational administration will never be quite the same again now that it has appeared. What is wanted now is a decision on priorities. Either those who would have left at 15 get another year at school and suffer the eventual consequences of the present inadequate preparation of the future engineers, scientists and administrators on whom they will demand for employment, or a real effort will be put into placing some of the best graduates in science and engineering teaching not only in the sixth forms but in the colleges of advanced technology.

Wage Claims

Not for 23 years have the building trades workers had to agree with their employers across the negotiating table that there was no movement in the retail prices index on which a wage claim could be based. That being the case, a claim for 4*d* an hour more for building trades workers has still been made and it has been agreed that it go to a sub-committee for negotiation. Last May the Industrial Court rejected a 4*d* an hour demand and the employers estimate that the full concession of the claim would add £40 million to costs.

On the railways Sir Brian Robertson's offer that any pay award should be back-dated to 11 January has not produced a softening effect on the decision of the London district council of the National Union of Railwaymen who still propose to hold a one-day strike on 1 February. But there are signs, as in the defection of the goods and cartage workers at Manchester and Salford from a local decision to support the one-day strike, that large groups of railwaymen who could be affected by the strike decision will turn up for work. Not only is the union's secretary, Mr. Sidney Greene, urging the men patiently to await the outcome in April of the pay inquiry, but the London district secretary, Mr. S. Hoskins, has offered his resignation because he believes the strike should be called off following the Transport Commission chairman's promise.

In the bus transport concerns all three branches, private, municipal and London Transport, now have claims in, either for a substantial increase or for £1 a week more. London Transport Executive have rejected the claim.

In the engineering industries the next significant wage date is 26 January. The engineering employers will then reply to the renewed £1 a week more and a 40 hour week claim of the Confederation of Shipbuilding and Engineering Unions. So far they have refused the increase and offered a 42½ hour week.

It is uncertain whether the attempts by a section of the more militant shop stewards to organise sporadic token strikes in engineering firms will receive any support, but it is not the belief of union leaders that support is entirely lacking.

And as if they had not troubles enough, it is clear that before long the National Coal Board will be facing a wage claim from the National Union of Miners, possibly for another 10*s* a week.

Rocket Astronomy at Science Museum

The Science Museum in London has on show a small exhibition on Rocket Astronomy which has been lent by the United States Navy. A camera which was recovered after being fired up in a rocket is part of the exhibition and is explained by a recorded voice commentary. The pictures include photographs of the sun taken from rockets and also picture series on rocket launchings.

Labour Party Labyrinth

The spectrum of the Labour Party's discussions extends from the darkest shades of those who regard deviations from "public ownership of the means of production" as flirtations with the devil, all the way to those who follow the Prime Minister and declare that their members have never had it so good.

Echoes of the latter could plainly be heard at a "Which Way for Labour" meeting in London last week-end where shop stewards from the Midlands and Scotland declared that their members had cars, intended to keep them, and wanted better cars next year.

Mr. Gaitskell may have felt uncomfortable reading the contribution to the same conference from the secretary of the National Union of Mineworkers, Mr. William Paynter. The "right-wing" trend in Labour discussions was directly described by Mr. Paynter as "a cancer eating into the guts of the Labour movement." Mr. Paynter's following observation that Mr. Gaitskell approved of the arguments coming from the right of the Party was only one more of the accumulating pieces of evidence that go to show the leader of the Opposition is unlikely to be able, should he wish, to achieve what Mr. Attlee (now Lord Attlee) was widely credited with, a position of above-the-battle detachment.

The arguments within the Labour Party are important to industry for three reasons. There is a close link with the trade unions and industrial relations, there is the effect on trade of the overseas assessment of the situation, and there is its final outcome upon whether or not Labour have a second run as the parliamentary majority.

It now seems incontrovertible that the Conservatives have established an election-winning connection between their Party's "image" and the general prosperity.

If that is so then the Labour Party has a long and tough road ahead to get out of the Opposition wood. Its apparent difficulties in interesting young people, especially in union affairs, are in that context a more serious liability than they at first appear.

Special Safety Steps at Beryllium Plant

Some of the most dangerous curves and corners on the roads are free of accidents simply because of the extra care that their obvious peril commands. In much the same way Imperial Chemical Industries have created in their new beryllium plant at Birmingham one of the safest factories in Britain in which to work.

Powdered beryllium, which is the form in which it is processed in the plant, is dangerous to the lungs if inhaled in significant amounts.

The £1,000,000 plant, which took a year to complete, has no windows and the minimum of contact between its workers and the outside world. They change from their own clothes into works suits before entering the "contact" area. On leaving it each man has to take a shower before resuming his own clothes.

The air in the plant is changed every three minutes, 200 tons of air an hour passing through the filters and heaters. The 200 workers, who have sometimes to don futuristic suits for special operations, are operating a plant with an annual capacity between 7 and 10 tons. Beryllium costs £160 a lb.

Victoriana in Telegraphs

Whatever it was Mr. Gladstone said in 1865, it is reasonably certain that reference was made to it over the telegraph. Four years later, in 1869, the formidable Victorian announced the terms of compensation for the transfer of the telegraph systems to the Government postal services.

Mr. John Durham, in *Telegraphs in Victorian London*, published by the Golden Head Press, of Cambridge, has told with full period atmosphere the brief story of two of the telegraph companies, the London District Telegraph and the Universal Private Telegraph.

As in so many 19th century stories of achievement, the efforts of private individuals overcame the first obstacles. By the mid-century, telegraph wires were common enough on poles along the railway, but in towns they went underground at considerable cost and inconvenience. In 1857 two brothers, Sydney and Alfred Waterlow, whose business had premises 450 yards apart in the City, became the pioneers of overhead telegraph lines in the centre of cities in this country. The estimate for an underground cable between their offices was £1,200, perhaps an unreasonably high one, but enough, compared with the cost of two office boys, to put it out of court.

The firm of Alexander Bain, the telegraph pioneer, quoted £35 to £45, with instruments, for an overhead connection. Despite doubts about the permission of the Commissioner for Sewers, and the contention of the Drapers Company that their freehold went "from the centre of the earth to the canopy of heaven," the Waterlow brothers went ahead.

Following their example, engineers and financiers set up the London District Telegraph Company, with a target of 100 offices within four miles of Charing Cross. It had telegraph offices, telegraph clerks, delivery boys and, as even now, the ominous envelope. The United Private Telegraph company was much more like a forerunner of our telephone system. The company provided equipment and lines connecting businesses and private houses direct.

The District Telegraph, a great source of public attention and newspaper opinion, ran its poles and wires over the London roofs, but only slowly established itself. Not until 1865, seven years after opening, did it make a surplus, of £242 7*s* 11*d*. The slow and cumbersome methods of the District company and failure to use the central exchange switchboard in use elsewhere, were at the root of its reputation for extreme delay and doubtful accuracy.

As soon as a technical journal of the day reported that take-over terms by the Government were likely the District seemed to gather new life, its capital was increased and its name changed to London and Provincial Telegraph Company. But in 1869, speaking on the Telegraph Bill, Mr. Gladstone was able to announce the terms of compensation which ended the District company. Its shareholders received £64,000.

Power Direct from Hot Gas

A proposed generator uses the principle that a conducting fluid moving across a magnetic field should produce an electric current. Hot gases from a furnace are proposed as the fluid.

Although widely used, boilers and turboalternators are a somewhat inefficient way of generating electricity. Much research is being undertaken to find a more direct method. Two have already shown some promise: thermionic and thermoelectric generators. A more recent suggestion is that electricity should be generated directly from a hot gas, by taking advantage of its ability to conduct electricity. When such a gas flows across a magnetic field an electromotive force is induced in it. By inserting electrodes into the gas stream it should be possible to obtain electricity directly from the gas. Conventional boiler plant and turboalternators would not be necessary.

Generating electrical power direct from a conducting fluid is not a new idea. But it has only been made a practical possibility in recent years. Studies of rocket re-entry and the behaviour of gases in shock tubes have provided data on the conductivity and behaviour of gases at high temperatures. These have led to the possibility of a more realistic examination of direct power generation schemes.

A three-month study of a proposal for generating electricity direct from combustion products of a coal-fired furnace has been carried out jointly by the Avco-Everett Research Laboratory and the American Electric Power Service Corporation. The scheme studied is shown in the diagram above. An open cycle plant was chosen for simplicity and rough estimates obtained of the costs likely to be involved. Performance of the coal combustion products at the extremely high temperatures involved—factors such as the effect of "seeding" agents in promoting ionisation, the likely values of the heat-transfer rates, and dissociation values—was predicted from ballistic missile experience.

In the 450 MW plant studied, a reheat steam turbine was incorporated to increase the efficiency. The turbine drives a compressor, producing air at a pressure of 140 lb per sq. in. This passes through a heater downstream of the main generator and the emergent air at 3,600° F enters the combustion chamber. Coal combustion then produces a mixed gas at 5,300° F. Potassium chloride might be used to enhance the electrical conductivity.

The high temperature gas flows out through a venturi nozzle between the coils of a large electromagnet, which itself requires an excitation of 18 MW. As the gas flows across the magnetic field, strong electromotive forces appear at right angles to the field and the direction of movement of the gas (right hand rule). Electrodes at the edge of the gas stream should be able to draw off 360 MW of direct current at this stage.

From the generator section, the exhaust gases, at 4,200° F, pass through the regenerative heater and the steam generator. The latter, besides driving the compressor, generates an additional 107 MW of alternating current. Overall thermal efficiencies of 60 per cent are predicted, the net heat rate being 6,200 Btu per kWh. In practically all features, the performance of the generator improves in larger sizes. Mercury arc inverters are used to convert the main direct current output (at 2,500 volts) to alternating current.

CAPITAL COST COMPETITIVE

A small generator producing 10 kW of electrical energy has been tested at the Avco-Everett Research Laboratory, Everett, Massachusetts. Its performance, which approximates to that predicted, has been used as a rough guide for tentative estimates of the likely costs of generation by this method. A table of capital costs for the proposed plant appears on the right

The principal capital investment burden in the proposed plant is the requirement for a.c.-d.c. conversion equipment. This makes up a large part of the capital cost of the entire plant, amounting to $40 per kW. (Conversion efficiency would be about 96 per cent.)

Table:—Capital Cost of Plant

Equipment	Capital costs ($ per kW)	
	Conventional plant	Proposed plant
Steam generator and accessories	31	10
Steam-turbine-generator and compressor drive	38	12
Air compressors	—	4
Regenerator	—	7
Direct electrical generator	—	7
High temperature valves, ductwork and combustion chamber	—	4
Electrical converters and accessories	—	33
Reactive supply	—	5
Piping, pumps, heaters, and condensers	23	10
Building for converters	—	2
Totals	892	894

However, the capital cost of the proposed plant is comparable with that of conventional plant, while the likely efficiency (60 per cent) is superior to the best at present available (40 per cent).

HOW SOON?

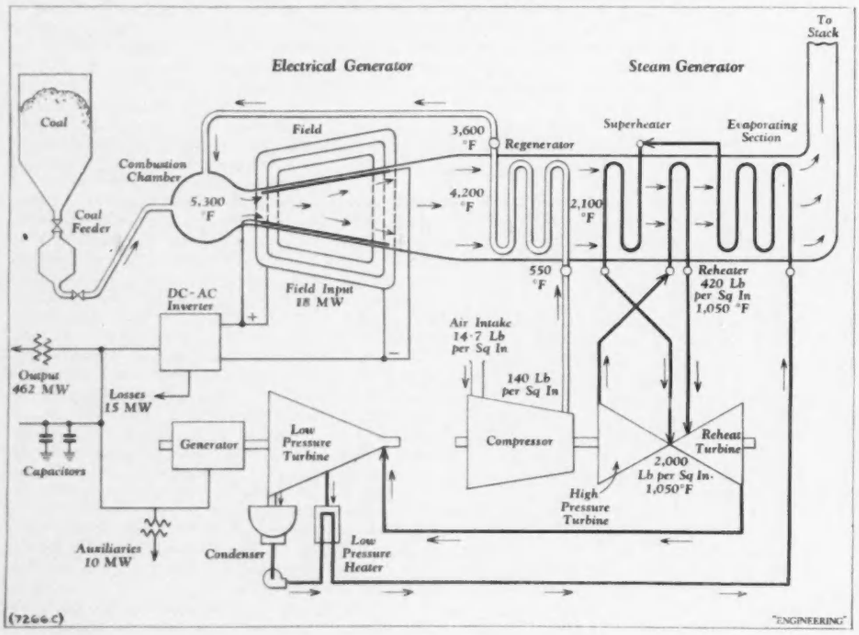
Dr. A. Kantrowitz, director, Avco-Everett Research Laboratory, and Mr. P. Sporn, president, American Electric Power Service Corporation, have this to say in answer to inquiries about the date of building the proposed plant. "This natural and intriguing question is premature and simply cannot be answered at the present time. At present we are nowhere near certainty that a plant like this can be brought into being, that is, that it is technically feasible . . ."

Their statement occurs in the November issue of *Power*, in which they describe the proposed plant in an article "Magnetohydrodynamics—Future Power Process?" Up to now in this article the use of that word—usually abbreviated to MHD—has been avoided because the proposed plant can be described (as, in fact, the authors mentioned above describe it) without reference to concepts peculiar to MHD. However—as the article on the opposite page points out—such simple descriptions of the interaction of ionised gases and magnetic fields can be misleading. Dr. Kantrowitz and Mr. Sporn emphasise this. "Formidable problems must be faced before a plant like this can be designed and operated. These consist mainly in understanding the stability of current paths in the gas, electrode effects, and other MHD phenomena."

The preliminary investigation suggests that there is a fair expectation that the theoretical and practical problems can be solved. Before accepting this, however, Avco-Everett are to undertake a programme of research to explore the new concept of power generation more fully. The programme will be sponsored by 10 US electric power companies. Essentially, it will consist of the following: a study of the basic principles of electric generation by a hot conducting gas stream interacting with a magnetic field, including a study of generator types; the development of high temperature materials suitable for use in the generator; a study of electrical conductivity in gases, including search for superior seed materials and refinement of collision cross-sections; and engineering and economic studies of overall power plant design. Satisfactory conclusion of this first stage of the work would lead to the production of a small prototype plant.

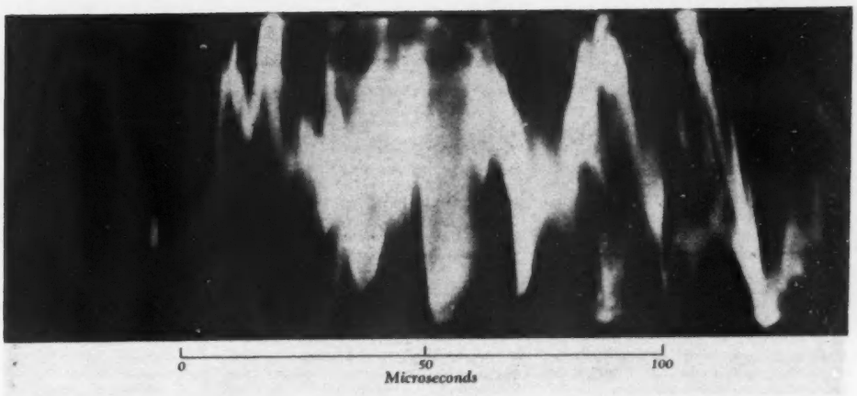
A similar programme has been announced by the Central Electricity Generating Board. They are forming a team to study the possibilities of large-scale generation of electricity by low temperature plasmas and MHD methods. Initially the team will examine the scientific and commercial feasibility of the scheme, and will then be responsible for experimental work up to the prototype stage. As the Board say in their specification for the team leader, the post calls for a "broad outlook, originality, and initiative."

Coal combustion products flow across a strong, magnetic field and generate 360 MW of electricity falling in temperature from 5,300° F to 4,200° F. The exhaust gases are used for regenerative heating.



Magnetohydrodynamics Poses Problems

The complexity of the behaviour of conducting fluids is becoming more and more apparent. Types of motion may exist that we do not even suspect.



Streak photograph of 80,000 amp discharge in heavy hydrogen shows violent wriggling of discharge.

Physics research follows a modified form of Parkinson's Law: work expands to occupy available labour. Concentration of scientific effort on a problem leads to the production of a whole new set of problems. The number of elementary particles in atomic physics, for example, has increased in proportion to the number of workers studying them. More recently, the scientific effort amassed to attack the problem of thermonuclear fusion has produced as its chief result an awareness of the vastness and complexity of the problems to be found in magnetohydrodynamics (MHD for short).

MHD is the study of conducting fluids in magnetic fields. It is tempting to refer to it as a study of the fourth state of matter. But this could well be an earthbound simplification. It happens that we are familiar with a world in which three states exist: solids, liquids, and gases; but the greater part of the universe is made up of matter in quite a different state, whose complexity of behaviour even suggests its classification into a new series of states. Inside and outside the thin crust of the earth, ionised matter, or plasma, interacts in a complicated way that has yet to be understood.

When a conducting fluid moves in a magnetic field, electric currents are induced in the fluid. These modify the field and the motion of the fluid. It is the interaction between the field and the motion that leads to the special interest and difficulty of MHD. A familiar effect claimed for MHD is the earth's magnetic field. Hypotheses have been put forward to explain how the liquid core of the earth could move in such a way as to act as a self-excited dynamo. But a full analysis of self-dynamo action in a plasma has not yet been put forward.

The equations of MHD are familiar. It is their combination that results in complexity. The simplicity of electromagnetics, which results from its linearity, disappears when it is combined with gas dynamics, which are essentially non-linear. The electromagnetic equations concerned involve the relations between: (1) current and magnetic field (Ampere's circuital rule); (2) e.m.f. and rate of change of magnetic field (Faraday's circuital rule); (3) current and conductivity (Ohm's law).

These are combined with: (4) the hydrodynamic equation of continuity; (5) equation of motion, taking into account magnetic and gravitational body forces. In a compressible fluid, these equations have to be supplemented by a heat equation taking into account the combined effect of heat conduction, viscosity, and electric currents.

FIELDS—LEAKING OR FROZEN

The wide variety of circumstances in which MHD effects occur lead to various mathematical approaches, and also to attempts to introduce a revised terminology. Thus for fluids such as mercury, the term " hydromagnetics " is advocated; while " plasma dynamics " is offered as a label for the behaviour of ionised gases. Two basic mathematical approaches correspond to this terminology. The fluid can be treated as a continuum and an attempt made to produce something like the Navier-Stokes equation. Or the fluid can be treated statistically as an assemblage of particles, with the aim of working round to a modified Boltzmann equation.

The application of the six equations mentioned above to simple, idealised fluids leads to the emergence of some of the concepts and terminology peculiar to MHD.

If, for example, a uniform spatial distribution of charge is assumed, it is found that a magnetic field will diffuse and decay through it. The field is spoken of as " leaking " away. A calculation based on the assumption of a molten iron interior for the earth gives a time of free decay of its magnetic field as 15,000 years. Here the experimental difficulties of MHD appear. How can magnetic effects on this time scale be measured? Other MHD events on a cosmic scale present this difficulty to an even greater degree.

Another important MHD concept is " frozen " magnetic fields. If a fluid is assumed to be infinitely conducting, lines of magnetic field can be considered as dragged along by it when it moves. Movement along the lines of force does not affect the field, but when the material moves across the lines of force they act as though they were frozen into the material. Depending on the state of the material, either the " freezing " or the " leaking " effect can predominate. For the freezing effect to predominate, a quantity proportional to the dimensions and speeds characteristic of the experiment, the permeability and conductivity, called the magnetic Reynolds number, must be very much greater than 1. This is not so for liquid mercury under ordinary conditions, for example. The lines of force slip readily through it. But when cosmic dimensions and speeds are reached, magnetic Reynolds number of very high value occur and lines of force can be regarded as frozen in. In recent years plasma conditions with high Reynolds numbers have been achieved in the laboratory.

Many simple physical concepts become quite complex when attempts are made to apply them to MHD phenomena. Electrical conductivity, for example. When a plasma is moving through a magnetic field, the individual charged particles will move in spiral paths. Depending on the size of the experiment and the number of collisions with other particles during any one particle's movement along its spiral, the ease with which a charged particle can move under the influence of an electric field and the direction in which such a field will cause it to drift, will vary with direction relative to the magnetic field. It will be easier to produce a current along the magnetic field than across it. Conductivity becomes different in different directions. From being the simple scalar quantity of the electrical engineer, conductivity for the magnetohydrodynamicist becomes a tensor.

When such variations in conductivity with direction occur, the question arises whether this implies that magnetic leak through the material is increased in the direction of reduced conductivity. In fact it is not. Thus the same experiment can yield effects that suggest contrary conclusions—the conductivity has decreased and has not changed. So it is dangerous to apply normal physical concepts to MHD.

A further example of the perverseness of MHD behaviour is provided by another aspect of electrical conductivity. Normally, a perfectly conducting material cannot contain an electric field. But it is fallacious to expect electric fields in plasmas to be weak because the electrical conductivity is extremely high. Regions of different densities in the plasma can create strong diffusion forces. These lead to varying rates of movement of different types of particle and the creation of strong electric fields. And, as might be expected from previous examples, this affects other aspects of plasma behaviour. In Zeta, for example, temperature measurements were made by measuring the broadening of spectral lines—on the assumption that the broadening was due to the Doppler effect of rapid thermal motion. But intense electric fields could have contributed to the observed broadening and the real temperature might have been lower than announced.

Realisation of complexity of plasma behaviour has resulted in a changed attitude to apparatus such as Zeta and the proposed generator described on the opposite page.

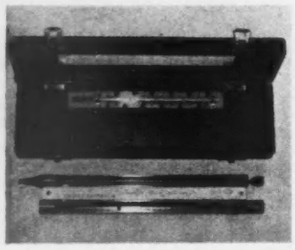
Study of pressure waves in ionised gases opens up a whole new field for experiment and theory. We know very little about turbulence in a compressible fluid in which the energy content of the turbulence is comparable with that of the shock-wave field; the possibilities of supersonic turbulence have yet to be investigated. Only when simple plasma situations have been understood can the difficult problem of the partition of energy between turbulence, pressure waves, and magnetic field fluctuations be tackled.

Laboratory studies of MHD, notably in connection with thermonuclear research, are changing in emphasis. While large machines such as Zeta are still in operation, there is a growing number of smaller, simpler experiments being undertaken to attempt an understanding of the basic principles of plasma physics. Teams with modest resources are able to play a valuable part in this way.

Studies are being carried out with simple shock tubes, producing plasmas at high Mach numbers—of the order of 100. Or the modes of plasma waves in pipes (plasma waveguides) are being examined. Other experiments, such as those carried out in the Hydromagnetics Laboratory of the Enrico Fermi Institute, are concerned with the properties of liquid metals. At Chicago, for example, a dish of mercury is rotated between the poles of a cyclotron magnet and the effect of magnetic field strength on convection currents when a dish is heated from underneath is noted. These and similar experiments are laying the foundations for the establishment of MHD as a coherent branch of physics.

VISCOSITY COMPARATOR

Spot Checks



THE CD viscosity comparator is designed for spot checks of lubricating oils to be made quickly and easily.

Basically the instrument consists of a pair of rolling sphere viscometers built as a single unit. One of the tube assemblies is used as a reference and is filled with certified oil. The scale is calibrated for a temperature of 70° F; a simple correction can be applied for other temperatures.

The two tubes are mounted parallel in a frame and the test tube is fitted with a plunger and nozzle to permit easy filling.

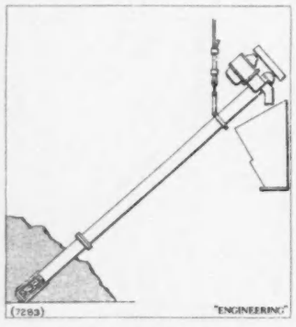
To carry out a test the sample is drawn in and the two balls brought to one end. The instrument is then tilted and the balls allowed to roll slowly towards the other end. When the leading sphere approaches the full scale mark the tubes are slowly tilted back to the horizontal so that the sphere comes to rest at the mark. The position of the other sphere then indicates on the scale the viscosity of the oil being tested.

Test records and correction charts are provided with the instrument.

The instrument and case weigh 1 lb 6 oz and the case measures 10½ in by 3½ in by 1½ in approximately. A range of standard calibrations is available suitable for use with all grades of oil in common use. Other models are calibrated for particular oils or have both tubes fitted with nozzles and plungers. Versions with stainless steel contact parts are also in production. The instrument is particularly convenient for checking the dilution of lubricating oil by fuel oil in diesel engines. *Control Developments Limited, 30 Gloucester Street, Gorton, Manchester 18.*

SCREW ELEVATOR

Self-Contained



A SELF-CONTAINED screw elevator designed primarily for handling boiler house smalls has a capacity for 1½ tons per hour.

The elevator consists of a steel tube in which a worm rotates in sealed self-aligning ball bearings. It is driven at constant speed by a totally enclosed motor mounted at the top of the casing. A short standard chute extends from the head and an additional section or breeches piece can be added which can be swivelled to suit site conditions. At the tail the worm is exposed to permit the entry of material. An adjustable strapping allows the head of the conveyor to be supported from any suitable structure overhead.

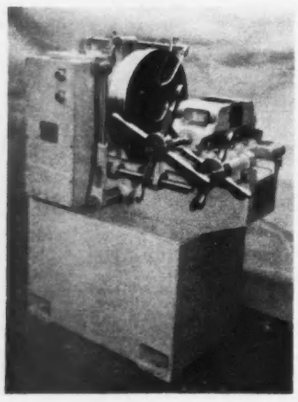
Each unit will handle up to 1½ tons of smalls per hour and feed direct to the hopper, simply by resting the tail on the stockpile and suspending the head in the required position. The elevator is said to be self-cleaning and the bearings are intended to run without attention during its life. Erection is simple and the unit can be moved from place to place without any difficulty.

The elevator is available in six standard lengths, 13 ft, 14 ft, 15 ft, 16 ft, 17 ft, and 18 ft.

Apart from its primary purpose of boiler house fuel feeding where there is no pit or hopper the elevator can be used for all similar applications involving material of about the same size. *James Hodgkinson (Salford) Limited, Ford Lane Works, Broad Street, Pendleton, Salford 6, Lancashire.*

THREADING MACHINE

Up to 4 in Pipes



THE threading machines types UR and UT of the Heap range have recently been redesigned.

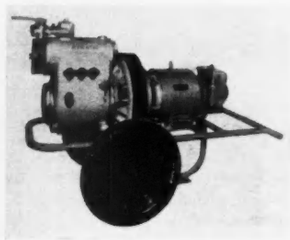
A larger cabinet base is used solely for the collection of swarf and as a tank for cutting lubricant. The saddle has been made very powerful with two pairs of vice jaws for gripping the work.

The drive to the headstock is from a 3 h.p. motor, which is flange mounted, through a flexible coupling and pick-off gears to the worm shaft. Four spindle speeds are available—6, 11, 21, and 38 when fitted with the type UR diehead, and 11, 21, 38, and 74 when the type UT head is used. Both drive shaft and worm shaft are mounted in ball bearings.

With either the UR or UT head the capacity is from ¼ in to 4 in for pipes either taper or parallel thread, and from ¼ in to 2 in for bolts. The UR is a radial head that incorporates a receding mechanism and lever release. It can be opened and closed while the machine is running. The type UT is a tangential form and is not fitted with lever release. A receding mechanism is, however, incorporated to enable taper threads to be cut. Tapping equipment, die grinding fixtures, roller steadies, etc., can be supplied for use with the machine. *Joshua Heap and Company Limited, Oldham Road Engineers Tool Works, Ashton-under-Lyne.*

COMPRESSOR

Quiet Running Machine



AN addition to the Hymatic range of air compressors is the 45E90 machine illustrated.

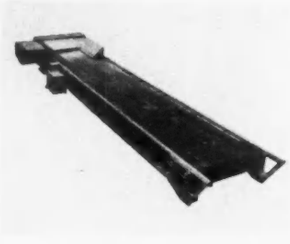
The unit has a displacement of 45 cu. ft per min and a working pressure of 90 lb per sq. in compared with the figures of 40 cu. ft and 85 lb per sq. in of the 40E85 which it replaces. The chassis also has been redesigned to improve handling and reduce size. The output is sufficient to operate two CP9 hand drills or one Armstrong Whitworth size 17 drill at full power. Alternatively, there is ample air to run one medium tool such as a pick, spade or light paving breaker.

The trolley is mounted on large diameter pneumatic tyred wheels. As the overall width is only 28 in, the compressor can be wheeled through standard doorways. The length of 62 in and the height of 37 in, coupled with a weight of 650 lb, allow it to be transported in a builder's hoist.

The compressor unit is a Hymatic-Hydrovane oil-sealed rotary set directly driven by a 10 h.p. three-phase electric motor fitted with a star-delta starter. Built-in equipment includes air intake filter, automatic pressure control, pressure gauge and safety valve. The use of oil for internal sealing and the absence of reciprocating parts make for high efficiency and reliability. The only maintenance normally required is routine changing of the oil and of the intake filter. Clean air and silent running are two of the main claims for this unit. It is said therefore to be very suitable for use inside buildings where too much noise would cause disturbance. *Hymatic Engineering Company Limited, Redditch, Worcestershire.*

CONVEYOR

Self-Contained Unit



THE Miniveyor has been designed primarily for use underground in making stable holes at the advance faces of long wall mining operations.

Essentially it consists of a light weight all-steel frame of welded construction with electric motor drive incorporated in the pulley assembly at one end, and an adjustable tensioning pulley at the other.

The entire unit can be mounted on 8 in castor wheels or on skids so that it can be moved and positioned easily. The motor is rated at 2 h.p. and can be supplied from a standard drill panel. Belt speed is 175 ft per minute, which gives a rate of coal conveyance of 50 tons per hour. A removable hopper can be mounted above the driving drum to facilitate loading.

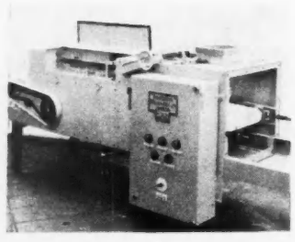
The unit employs a belt 18 in wide, but the maximum overall dimension is only 2 ft 8½ in. This is achieved by taking the motor leads to a junction box on the side of the conveyor. The overall length of the standard unit is 11 ft 4 in with the pulley centres at 10 ft but other lengths are available from 8 ft to 20 ft 4 in. With wheels the overall height is 1 ft 9½ in but with skids this is reduced to 1 ft 3 in.

The full range of sizes is 8 ft, 11 ft 4 in, 15 ft 4 in, 18 ft and 20 ft 4 in. The motor is rated for 2 h.p. at 125V, 50 or 150 cycles. Remote control starting is provided.

The conveyor can be used generally for many underground applications where its portability and compactness offer advantages in time saving, as for instance on breakthroughs or side passage work. *Joy-Sullivan Limited, Cappielow, Greenock, Scotland.*

FEED CONTROLLER

By Weight



AN electrically-operated Feedometer has been added to the range of Adequate feed weighing machines.

The unit is for continuous process feeding or for battery operation to blend continuously any number of materials. It is designed to stand up to arduous conditions. The electric control relay equipment is contained in one cabinet together with the main starting contactor for the motor drives. Sensing of the weighing system is accomplished by intrinsically safe circuits of electronic relays. These operate additional relays which feed two adjustable timing units and which also provide the electrical interlocks.

The timing units operate the reversing contactors for the feed control motor, which is driven intermittently until the weight error is satisfied. The intermittent drive prevents continual hunting of the weighing system.

Various sizes of feeder are available giving a range of up to 1,250 cu. ft per hour of material, depending on the bulk density. The accuracy is also dependent on the material but is reported to be of the order of 1 per cent over a two minute period.

The endless belt can be either rubber or pvc and is supported on idlers and terminal pulleys running in self-aligning self-lubricated ball bearings. Machines can be totally enclosed if desired. Hoppers with or without agitators can be used for the feed to the weigher, or else a variable speed belt for coarser material. Automatic cutout and warning signals are incorporated to cover feed failure. *Adequate Weighers Limited, Bridge Works, Bridge Road, Sutton, Surrey.*

DISCHARGER

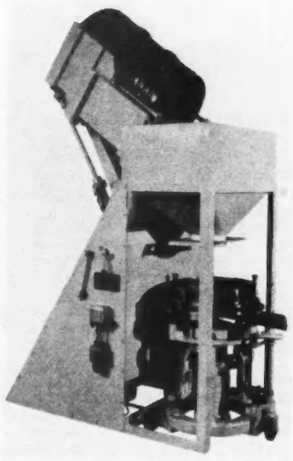
Handles Sacks or Drums

A DISCHARGER for emptying sacks or drums has been developed for general factory use.

The " Liftip " can be positioned close to the receptacle into which the contents are to be emptied and the discharge height can be from 3 ft to 8 ft above ground. Alternatively it can be supplied with a steel hopper as in the illustration, fitted with a discharge gate.

The machine has a steel frame with two lifting arms operated by independent hydraulic rams which lift and tip the hopper holding the container. The drive is by a 3 h.p. motor, running at 1,425 r.p.m. from a 400/440 V three phase supply, which is direct coupled to a hydraulic pump. Quick-release clamps are provided for holding the drum, bin or carton in position and for sacks a special retractable steel claw is used.

Prelubricated self-aligning bearings are used throughout and maintenance is slight. The unit is robustly constructed and silent in operation. It weighs approximately 5 cwt and the lifting



capacity is 6 cwt. It can also be supplied on wheels. *Russell Construction Limited, Russell House, Adam Street, London, WC2.*

PORTABLE WELDER

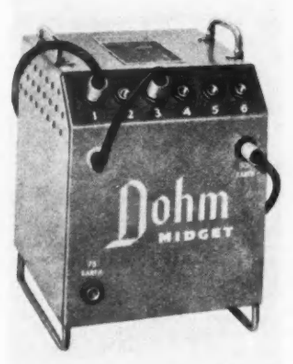
Up to 320 Amperes

SMALL flexible welding transformers for mains use have now been introduced known as the Midget.

The Midget has a single output of 160 A at 50 volts open circuit, or 120 A at 75 V. There are two models, one for use on single-phase supplies only and the other for one, two or three-phase supplies. Both have fifteen variations of current output on each range and are capable of working with electrodes from 16 to 8 gauge. Normal supply is at 200/250 volts alternating current.

A larger form, the Twin Midget, has provisions for two operators to work simultaneously, allowing each up to 160 A. When there is only one operator, the output can be up to 320 A. Normal supply is at 200/250 V alternating current and can be from one, two or three-phase systems. There are 52 variations in current in each of the ranges.

In both machines the transformers are double-wound and varnish insulated. There are no moving parts and therefore no maintenance is needed. The cases



are constructed from $\frac{1}{8}$ in steel plate with a stove enamel finish in silver hammer grey. The Midget is fitted with folding carrying handles as shown and the Twin Midget is mounted on castors. Both are claimed to be very light to move. *Dohm Limited, 167 Victoria Street, London, SW1.*

ROUTING ATTACHMENT

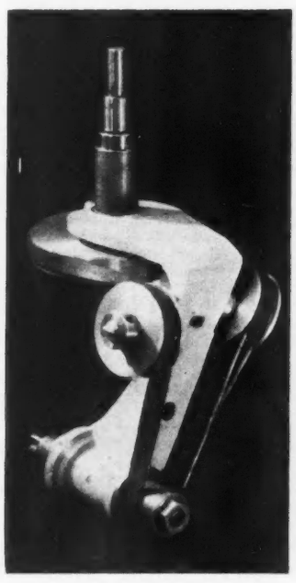
Cuts 5 in Deep

A VERTICAL routing attachment has been produced for use with standard square chisel mortising machinery.

The attachment is capable of a wide range of woodcutting operations including trenching, mitring, tenoning, etc., to a maximum depth of 5 in. The tool may also be used for cutting plastics. No modifications to the machine are needed.

The holder shank has the same diameter as the chisel shank, $1\frac{3}{16}$ in, and the $\frac{1}{2}$ in driving shaft also corresponds. Alternative sizes are obtainable. A small universal coupling is provided for the shaft to overcome any slight misalignment or wear. Standard routing cutters with $\frac{1}{2}$ in parallel shanks are used.

The drive is taken from a 5 in pulley over jockey pulleys to a $1\frac{1}{4}$ in cutter spindle giving a spindle speed of approximately 12,000 r.p.m. One jockey is mounted on a crank for belt tensioning. *B. S. Varley, 16 Padiham Road, Sabden, near Blackburn, Lancashire.*



RECORDER-CONTROLLER

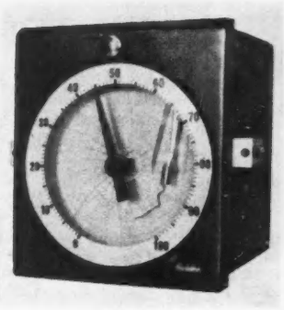
Transistorised

THE Servograph is a transistorised servo recorder designed to fit the range of Capacipoise instruments, all of which operate at 12 V d.c.

The size of the instrument has been chosen to give a chart of $6\frac{1}{4}$ in diameter while still only taking the minimum of panel space. The pointer moves over an arc of 300°. The indicator scale is 15 in long and is easily readable at some distance.

Both the pen and the indicating pointer are motor driven and no errors are introduced by pen to paper friction. The servo motor also ensures that extremely small increments are transferred to the graph. Moving parts have been reduced to a minimum; gearing has been eliminated by using a rim drive, and a quadrant connects the pointer to the pen. With this arrangement the amount of maintenance is reduced.

Since the input is isolated from earth, the Servograph can record any current or voltage normally indicated on a



meter and is suitable for recording the output of other electronic instruments. The minimum values for full scale deflection are 25 μA or 30 mV. Two models are made; for the first the power is supplied externally but in the second is a power pack allowing it to be operated direct from the mains supply at 240 V 50 cycles. Overall dimensions are $8\frac{1}{4}$ in by $7\frac{3}{16}$ in by $6\frac{11}{16}$ in deep; the power pack increases the depth by 3 in. *Fielden Electronics Limited, Wythenshawe, Manchester.*

AEROFOIL FAN

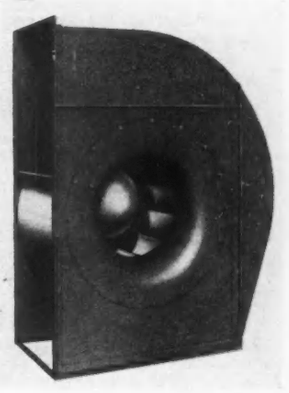
High Efficiency High Velocity

AN addition to the Cyclone range of fans is a high efficiency aerofoil model.

A maximum efficiency of over 90 per cent is claimed for this design, which is particularly suitable for air conditioning and ventilating installations where large volumes of air have to be handled at comparatively high pressures and especially for high velocity systems. The fans are available in sizes ranging from a 20 in inlet diameter to 10 ft.

The impeller carries mild steel blades of aerofoil section welded to a robust steel back plate and shroud plate. The fan casing is built entirely of steel plate welded throughout and braced with steel T's and angles, and incorporates a spin inlet cone. The casings can be supplied for either right or left-hand rotation and with any one of eight discharge positions.

Ball and roller bearings are fitted to the cast iron bearing pedestal or, alternatively, to the built-in bearing bridges which are secured, complete with legs,



to the fan sides. The shaft is precision ground or turned according to size. The drive can be by V rope or direct coupled to a motor. Where extra large volumes are involved, or where the head room is limited, double-inlet double-width fans are available. *Matthews and Yates Limited, Swinton, Manchester.*

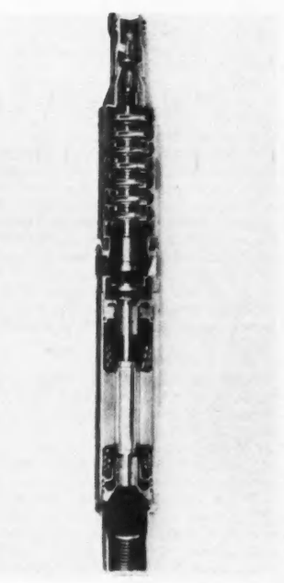
SUBMERSIBLE PUMP

4 in Hole

SERIES B submersible pumps—the Short Fours — incorporate Clam-seal motors and sand slinger vanes on the impellers.

The pumps are designed to fit in boreholes down to 4 in diameter and are made in nine models. Deliveries range from 100 to 1,100 gallons per hour at heads from 50 to 700 ft. All pumps can be fitted with either three or single phase motors and run at about 2,900 r.p.m.

Each impeller is fitted with sand slinger vanes and the diameters have been increased over early sizes, enabling the pumps to work against higher heads. The Clam-seal motors were designed to operate in sand-laden water and there is a radial seal barrier between the borehole water and the motor interior. The latter is filled with a low-viscosity oil maintained at pressure by a spring loaded neoprene reservoir in the base. No site priming is required. Pump outlets are screwed 1 in. *Sumo Pumps Limited, Crawley, Sussex.*



Physical Society Exhibition *18-22 January 1960*

The Physical Society Exhibition is an event in the year to which designers, makers and users of scientific instruments look forward. The majority of the exhibits are in the prototype stage and the whole atmosphere is one of ideas. The *Handbook* alone forms a reference book of developments during the past year.

This is the 44th exhibition to be held, and both Old and New Halls of the Royal Horticultural Society are well filled. It is a meeting place for scientists and research workers where they can discuss their problems and see the trend of work in other establishments. On this page a few of the exhibits are described.

TELEVISION CAMERA TUBE

With Memory

A TUBE for a television camera that has a "memory" is one of the new developments by EMI.

The special vidicon pickup tube has been developed to enable transients to be studied in more detail than would be possible with conventional means. The memory allows the tube to store an image for several seconds after the object has passed out of sight.

The tube has a specially prepared photo-conductive surface with integrating and storage properties. Tubes of this kind can be used for systems conversion, for example, to present a radar picture as a bright stationary television display. At the exhibition the properties of the tube are being demonstrated simply as a method of recording slow transients on a cathode ray oscilloscope. *EMI Electronics Limited, Hayes, Middlesex.*

DATA RECORDER

Sub-Miniature Unit

A SUB-MINIATURE magnetic tape flight-data recorder is now available that will provide a very small and compact multi-channel tape transport mechanism for missiles and other purposes.

The tape is carried on spools mounted in a reloadable cassette which also contains the mechanical take-up, supply spool drives and tape tensioning. This has the advantage that no drive of any sort is required to the cassette.

The unit measures 4½ in by 5 in by 3 in deep and the tape capacity is 500 ft. The recorder can be supplied for tape speeds anywhere in the range from 30 in per second down to 0·1 in per second, and normally provides for eight channels in line on a single head. The power consumption is approximately 5W and the weight of the unit in an armoured steel cassette is approximately 16 lb. With a light alloy cassette which is strong enough to stand up to most duties even in missiles the weight is reduced to 11 lb. *Royston Instruments Limited, Chertsey, Surrey.*

THERMOCOUPLES

For Temperatures up to 2,800° C

THREE thermocouples are now available that are capable of measuring temperatures above the range of platinum and platinum-rhodium combinations.

The first is an iridium versus 60 per cent iridium/40 per cent rhodium couple which is recommended for use under oxidising conditions at temperatures up to 2,000° C. The temperature-e.m.f. relationship is nearly linear, and the stability good.

Second is an iridium versus tungsten couple which requires the protection of a neutral atmosphere, preferably argon or helium. The temperature-e.m.f. relationship is again nearly linear. It may be used at temperatures up to 2,300° C and possesses excellent stability of calibration.

The third is a tungsten versus tungsten/rhenium couple which requires protection by a neutral or reducing atmosphere. It extends the temperature range up to 2,800° C, but is not linear. *Englehard Industries Limited, 52 High Holborn, London, WC1.*

INFRA-RED SPECTROMETER

With Recorder

MODIFICATIONS have been made to the SP100 infra-red spectrometer to improve the operation and maintenance.

The new spectrometer is a prism/grating double monochromator instrument with an auxiliary slave recorder, the whole being mounted on wheels. In the vacuum system a valve has been added to isolate the evacuated optical system from the pumping line. The cold trap is now located conveniently in the pumping line.

The wavenumber counter has been changed so that it is no longer necessary to reset it when the cams are interchanged. The speed ratios can now be selected instantaneously by electrical switching from the operation panel and the source unit is mounted externally with an adjustment for fine focus.

The electronic layout has been revised to make use of plug-in computer chassis for easier servicing. The cooling system has been improved. *Unicam Instruments Limited, Arbury Works, Cambridge.*

APERTURE DISCS

Down to 0·005 mm

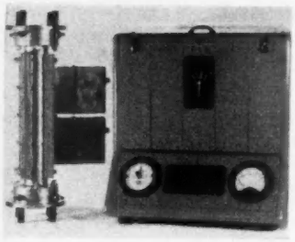
DEVELOPED primarily for use with electron microscopes is a range of aperture discs with concentric holes down to 0·005 mm in diameter.

The discs are made of molybdenum or platinum for use as lens or condenser apertures in electron microscopes. The concentricity is accurate and the holes range in steps of 1 micron from 0·005 mm to 0·5 mm, and in steps of 10 microns up to 1 mm. The range of platinum discs is normally from 0·005 mm to 0·050 mm and for molybdenum from 0·020 mm upwards. A tolerance of ± 0·0005 mm is possible on the finer sizes; on the larger ones it is normally ± 0·001 mm. Outside dimensions are to fit standard microscope sizes.

The discs are finally cleaned by a high temperature vacuum burn-off to remove any trace of impurity, a treatment made possible by the high melting points of the two materials. Precision drilled holes for gas flow control are also made. *Engelhard Industries Limited, 52 High Holborn, London, WC1.*

FLOWMETER

No Resistance to Flow



A FLOWMETER has been developed jointly by the British Scientific Instrument Research Association and the National Research Development Corporation which allows a perfectly free passage for the liquid.

The principle on which it works is that sound waves travel at different speeds with and against the flow, and therefore the difference in times will give a measure of the rate of flow of liquid. As a rule two inserts have to be fixed in the wall of the tube but they can be machined to give a smooth flush surface.

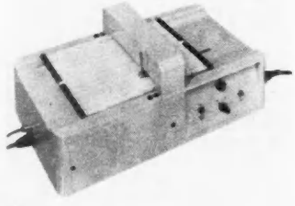
Two transducers spaced along the pipe radiate into the fluid. The time taken for the two signals propagated in the direction of flow and against it to travel between the transducers is measured as the phase difference between the two continuous signals. Since the measurement in both directions is made simultaneously between the same pair of transducers, the conditions under which the measurements are made are identical for both directions. The measured phase difference therefore indicates the flow velocity.

The flowmeter can be scaled to cover a wide range of pipe sizes from about 1 in upwards, and transducers may be designed to withstand a considerable range of temperature and pressure, the Association report.

For absolute accuracy the flow requires calibration, but linearity and repeatability appreciably better than 1 per cent can be achieved. The instrument is quite satisfactory for use with highly corrosive fluids or when there are solids in suspension. *British Scientific Instrument Research Association, South Hill, Chiselhurst, Kent.*

FLAT BED RECORDER

General Work



A RECORDER with the chart running on a flat bed has certain applications for which the usual rotating drums are not suitable.

The instrument illustrated is a prototype model which was destined primarily for spectroscopic and wave analysis purposes. It can, however, be used for any application involving a discontinuous process that also has definite start and stop points.

Presentation of the information is on a flat chart measuring 30 cm by 20 cm which is driven past the carriage carrying the recording pen. It is possible to select either linear or logarithmic recording scales as desired. With the former the full scale deflection corresponds to 10 mV and with the latter the full scale deflection is given by 200 MV. The response time of the pen is nominally 0·7 sec for full scale movement.

The chart in its holder is driven from a synchronous electric motor through a gear chain drive. The drive allows a choice of speed ratio of 1 : 1, 2 : 1 and 4 : 1 to suit the conditions. The drive is engaged through a magnetic clutch which is designed so that movement can be started and stopped at any required instant.

The recorder may be operated from a synchronous input, as for example when used as a spectrometer slave recorder, or, alternatively, it may be used as a normal independent function recorder, driven from a separate electrical supply.

The controls, consist of mains and carriage travel switches, linear or logarithmic selector, and an indicator light. *Unicam Instruments Limited, Arbury Works, Cambridge.*

NOISE ANALYSER

Rotating Machinery

ORIGINALLY developed for the testing of automobile gearboxes, this noise analyser can be used for any rotating machinery.

There is a choice of two fixed band widths and the tuning of the analyser is automatically adjusted to suit the input shaft speed. In addition to a noise or vibration transducer, the only accessories required are the series of toothed wheels with a magnetic pickup, the wheels being mounted on the drive shaft. The number of teeth on each wheel is chosen to suit the various gear meshes of the box being examined, and the frequency of the signal derived from the magnetic pick-up sets the tuning frequency of the analyser.

The pass band is rectangular in shape and there is a rejection of more than 50 db of the signals outside the band. The instrument will operate over a range from 2 to 20,000 c/s. It can also be operated as a conventional wave analyser. *Royston Instruments Limited, Hanworth Lane, Chertsey, Surrey.*

PLAYBACK UNIT

With Continuous Loop

A COMBINED spool magnetic tape playback unit with an additional continuous loop has been designed to serve as a means of re-presenting a single sample in a repetitive form for continuous analysis.

A tape recorded at any speed may be played back, viewed and edited either on pens or on an oscilloscope, and re-recorded on to a continuous loop which is operated from the same tape capstan as the spool transport. This arrangement avoids errors due to flutter. The tape is then replayed at a speed of 100 in per second so that, irrespective of the speed and input frequency of the original recording, there is repetitive output with frequencies covering a range from 0 to 10,000 c/s. In addition a pulse is obtained for each revolution of the loop.

A laboratory wave analyser can then be used or alternatively a switched filter unit followed by an integrator for more accurate work. *Royston Instruments Limited, Chertsey, Surrey.*

Fission Byproducts

It is a mistake to think of nuclear fission as the "crop" to be harvested in a reactor; the fission process is better regarded as a piece of agricultural land which can be farmed extensively or intensively. In the United Kingdom the farming is extensive: the unit size of power stations has been increased to the maximum; plans are made to accommodate more than two reactors at the same site; and the reactor stations are assured, at least in theory, of the highest possible load factor that can be expected under the usual conditions of power demand. But the generation of electromechanical power from thermal sources is like sailing against the prevailing thermodynamic winds: in this case the efficiency of an ideal engine operating between the temperatures of the available heat source and heat sink sets the limit. From a reactor producing 1,000 thermal megawatts, only about 250 electrical megawatts can be expected, the rest is wasted. An opportunity exists for a more intensive utilisation of the fission process—more intensive farming, so to speak—if part of the rejected power can be turned to better use than raising the temperature of the ocean and the atmosphere. The possibility is particularly important since only one universal conclusion seems to emerge from studies of hundreds of reactor systems using all conceivable combinations of moderator, nuclear fuel, conventional superheat, coolant and generating plant: the costs are higher than those of the best conventional stations.

Byproduct Heat or Back-pressure Power

Rejection of waste heat to some form of chemical process or domestic heating would be a reasonable solution except for two facts. One problem is that the thermodynamic efficiency of a nuclear power station is relatively low as a result of the limitations imposed on the maximum fuel element temperature. If heat is to be rejected from the power generation cycle at a useful temperature, the efficiency of the turbines would suffer. The other problem is that no single steady demand for byproduct heat can be found within reach of power stations. Where such demand is available, conventional stations have already taken advantage of it: some steel and paper mills generate their own power very economically. But if some of the power generated in a reactor could be used, not in the form of heat, but as radiation, a new field of application would be opened where conventional stations could not complete. Radiation is a very high grade of energy; in our power stations we first degrade it to heat, and then through a costly and inefficient process convert it back to electrical and mechanical energy.

Availability of Radiation

When the present programme of nuclear power station construction is completed, there will be a capacity of 4,000 MW (e) installed in seven stations. The thermal output will be a little less than four times that figure, say 15,000 MW(t). Dr. Henry Seligman, formerly head of the Harwell isotope division and now with the IAEA, estimates that about 2 per cent of the power of a nuclear station could be made available for commercial irradiation. By 1965 the United Kingdom will have a potential irradiation capacity of 300 MW, all of which will be absorbed in shielding and reactor components. Only some long half-life radioactive isotopes will be salvaged from irradiated fuel for commercial use, and the revenue realised will be of minor importance. In a year of normal operation, the seven nuclear stations will only produce about 10 megacuries of caesium 137, while the source requirements of a commercial irradiation plant may be of the order of 500 megacuries. Such powerful sources can be obtained in the form of shorter half-life isotopes such as cobalt 60 (5·27 years instead of 33 years), or directly from a reactor operating at high power.

By-product Irradiation

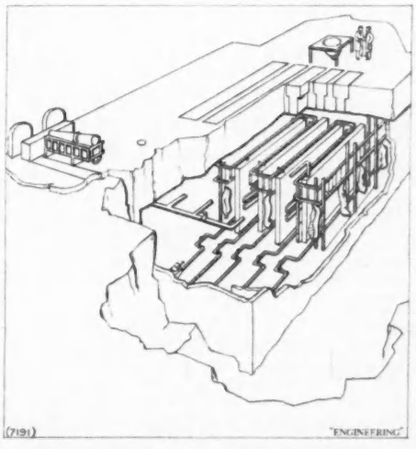
The advantage of using a power reactor as a large irradiation source lies in the fact that short half-life isotopes are available 70 per cent of the time (if that is the station's load factor) without any need for fuel handling, processing, extraction and shipment of highly active materials. The economic advantage is that the capital cost of a 1,000 MW(t) reactor, which produces only 250 MW of electricity, can be shared by the irradiation plant—if a steady demand for irradiation can be found.

Scope for Selling

It is difficult to assess the possible demand for irradiation facilities at the present because no concentrated effort has so far been made to find the potential users, to test the possible side-effects of irradiation, and to sell the idea to the manufacturers and the consumers. In every field of application, the seller of irradiation will face considerable competition from other fields. Relatively low level irradiation of potatoes and onions will prevent sprouting, but the same can be accomplished by chemical means. Preservation of food products, meat and prepared foods in particular, can be accomplished in a number of ways—from canning to freezing—in addition to irradiation. Rubber can be vulcanised with sulphur or by irradiation, and the desirable properties of cross-linked polymers produced by irradiation are matched by competing thermosetting plastics. And, as a final blow, particle accelerators can produce radiation as cheaply or cheaper than reactors in spite of the seemingly wasteful series of energy conversions employed.

Methods of Utilisation

Considerable experience is available with the direct irradiation of relatively small samples of materials inside a reactor. The method is not suitable for mass production and requires specially designed reactors usually using enriched fuel to compensate for the absorption of neutrons by the sample. As a commercial production plant it further suffers from the disadvantage that the material is exposed to a considerable neutron flux and the end-product may accumulate induced radiation. Slurry or liquid fuel reactors could be designed to circulate a portion of the fuel stream through an irradiation cell, but delayed neutrons would be troublesome unless there is considerable fuel hold-up in the system. In the latter case the capital investment in fuel would be exceedingly high. M. C. Crowley-Milling, in his paper "The Application of Irradiation in Industry," mentions the use of gaseous fission products as irradiation source, but points out that the emitted



gamma radiation is of low power (below 0·5 MeV) and would be lost in the walls of the fission-product containment system. It is conceivable that suitable low-absorption "windows" could be built to overcome this difficulty. More promising is the use of induced radiation in a reactor's normal coolant, or in a liquid preparation such as a solution of indium sulphate circulated through the reactor core. The Hallam sodium-graphite reactor may be the first such installation, as reported below. The United States Army had an ambitious programme for large-scale consumer testing of irradiated food, and this would have been based on a special reactor using an indium-sulphate loop as source. The project was later modified under controversial circumstances, and provision of the reactor was dropped in favour of a large cobalt 60 source (see below).

Process-Liquid Cooled Reactor

Perhaps the most promising application of commercial irradiation is in the chemical process industries. Construction of special organic-liquid cooled reactors has been suggested to serve as chemonuclear factories. The process liquid which is to be irradiated is passed through the reactor as the coolant and moderator. P. C. Aebersold, director of isotope development at the USAEC, estimates that from 7 to 8 per cent of the fission energy could be utilised in this way, and in addition the heat generated can be recovered for other purposes. To reduce induced activity in the process liquid, a certain amount of cadmium would be included in the core to "filter" out some of the slow neutrons. It is estimated by the USAEC that a 20 MW(t) reactor could process material at the rate of more than a million megarad pounds per hour, at a cost of about 10 cents per kWh. A typical dose for vulcanisation of rubber is about 5 megarad, and cross-linking of thermoplastics about 25 megarad.

Hallam Becomes a Mutli-Purpose Reactor

Certain modifications which will permit later

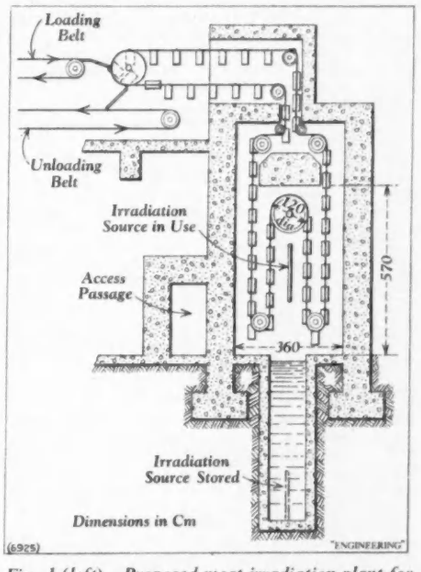


Fig. 1 (left) Proposed meat irradiation plant for the 75 MW(e) Hallam sodium-graphite power reactor, under construction in the state of Nebraska.

Fig. 2 (above) Potato irradiation plant.

installation of a food irradiation facility in the 75 MW(e) Hallam sodium-graphite reactor have been announced by Atomics International. Provision is made to divert a portion of the coolant stream in which residual radioactivity would serve as the irradiation source. Civil engineering work on the Hallam reactor is now well advanced and there is no immediate plan for construction of a processing plant. Fig. 1 shows a section of the proposed facility, which would be located adjacent to the reactor. A conveyor belt moves the food past sodium pipes in several passes, while T-shaped slots in the concrete shield permit access to the equipment. It is not yet known what effect addition of a processing plant would have on the generating costs of the reactor. The Hallam station is being built for the Consumers Public Power District of Nebraska, a rich agricultural area of the United States. The value of livestock produced in Nebraska in the year 1954 was over $500 million, so that operation of a meat irradiation facility might well turn out to be a highly profitable venture, if irradiated foods are found to have no harmful biological effects.

Potato Irradiation Facility

Large-scale irradiation of potatoes can be performed with the machine shown in Fig. 2. The potatoes are brought on rubber belts to the main conveyor. A transfer mechanism fills the buckets of the conveyor, which then makes four passes past a caesium 137 source. As governing of the belt is easier at higher speeds, the four-pass design was adapted to simplify the control of irradiation time. When the source is not in use, it is lowered into the well just underneath the irradiation chamber. With the source stored, inspection of the mechanical components of the conveyor is possible through the access

passage. (*Technischer Strahlenschutz by* T. Jeager, Karl Thiemig, München.)

Pilot Scale Production Plant

In the United Kingdom the Technological Irradation Group of the UKAEA is undertaking pilot-plant testing of irradiation processes. A facility is being built by the Owen Organisation at the Wantage Radiation Laboratories to process material at the rate of 2,200 megarad pounds per hour continuously. The plant is designed for the automatic handling of a basic package size of 1 cu. ft. When in full operation, the irradiation cell will contain 500 megacuries of cobalt 60, but the initial source strength will be only 150 megacuries. An elaborate conveyor system will move the standard packages past the slab source in ten passes. Two independent conveyor systems operate simultaneously, permitting a degree of flexibility in operation and the possibility of processing two dissimilar products at the same time.

Fuel Storage Pond Serves as Irradiation Facility

Spent fuel from the high-flux research reactors Dido and Pluto serves as irradiation source while stored in the Harwell cooling pond to reduce radioactivity. When the fuel elements arrive from the reactors, they are lowered into the pool and the end-caps are removed. The uranium fuel is placed in a cadmium sheath to absorb the neutron activity. The precaution is taken to prevent accidental criticality in the pond, where a large number of elements may be stored simultaneously. Also, the presence of neutron radiation is undesirable in an irradiation plant because of the radioactivity it induces in exposed materials. The pool is now being used both for research and production. Some ten thousand catheters and a number of disposable plastic syringes are sterilised weekly for hospitals. Polyethylene is also treated on a commercial basis in order to induce cross-linking of molecules, which raises the softening point of thermosetting plastics. Irradiation testing of future reactor components is undertaken, in particular the lubricants that will be used in the CGEB plants, and some radiochemical work is done for atomic energy establishments abroad.

US Army Stops Food Irradiation Project

It is not clear what caused the change in the United States Army's plans for a large food irradiation plant which was to be built at Lathrop, California: economics or danger to health. Mr. Richard Morse, head of the Army's research and development department, mentioned both when he announced cancellation of the programme in November last year. Unless startling new developments had occurred during the months preceding the announcement, the economic arguments are hard to accept as detailed plans had been prepared and some orders placed for major components: it may be assumed that the economic arguments for and against the plant had been well explored beforehand. Mr. Morse mentioned that animals kept on irradiated food had developed diseases which could be explained by simple vitamin deficiency. Although conclusive proof of avitaminosis is lacking, it would be surprising if limited animal tests were to be sufficient to cause a last minute cancellation of a $7·5 million project on which considerable sums had already been spent. The need to cut expenses may have been the prime mover that eased the Army out of irradiation business.

Notes and News

Italy Builds Organic Moderated Reactor

Construction of a 30 MW(t) organic-moderated power station will be undertaken jointly by Fiat, Montecatini, AGIP Nucleare and the government control body CNRN, according to an announcement of Radio Italiano. The decision was announced in Milan on 13 January, following a meeting of high level representatives of the four organisations. The reactor will be built entirely in Italy, but the design of reactor components may be based on the experience of Atomics International, who are building the 11·4 MW(e) organic moderated power station for the City of Piqua in Ohio. Fiat and Montecatini, representing a large proportion of Italy's capacity in the mechanical and chemical industries, have pooled their nuclear interests under the name SORIN, and operate a 1 MW(t) pool reactor of AMF design in Chevasso, near Turin.

Public Debate on Canadian Atomic Policy

At a public debate in Toronto on 13 January Winnett Boyd suggested a course of action for the Royal Commission reviewing Canada's nuclear programme. Appointment of such a commission was anticipated in the 1 January issue of Atomic Review. Mr. Boyd suggested as a first step appointment of experts to study the feasibility of an Anglo-Canadian enrichment project which would take advantage of Canada's low-cost electricity and abundant uranium supplies. The second task should be to investigate AECL's current practice of building water-moderated reactors without vapour containment in view of the accident that occurred to NRX. The requirement for vapour containment would eliminate the natural uranium heavy-water moderated reactor as a practical power plant owing to the large size of the core. Regarding the 200 MW(e) power plant Candu, Mr. Boyd suggested suspension of construction until experience with NPD-2, to be completed in 1961, confirms the designer's expectations. In the meantime, intensive development work on Candu, OCDR (organic cooled heavy-water moderated reactor project) and an active gas-circuit high-temperature reactor is urged, ensuring that regardless of the fate of NPD-2, Canada's nuclear programme will not suffer any discontinuity.

Graphite with 98·23 per cent Theoretical Density

Rocket research has produced a new form of impermeable graphite which has a density of 2·22 grammes per cu. cm, or 98·23 per cent of theoretical density. A process for making the material in commercial quantities has been developed by the Raytheon Company under contract to the US Navy, reported *Aviation Week* in its 7 December issue. Pyrographite, Raytheon's trade name for the material, will not vaporise under 6,350° F and will be applied as a protective coating for nose cones and re-entry vehicles. The key to Pyrographite's high density is a controlled deposition of molecular carbon from a carboniferous gas to attain preferential crystal orientation. The degree of orientation, and hence the resulting density, varies directly with the temperature of deposition. Hitherto, graphite density has been increased by various methods of impregnation. (See Metals and Materials, p. 110 of this issue). When applied to fine grain nuclear grade graphite, two stages of impregnation will result in a density of 1·8 to 1·9 grammes per cu. cm, or only about 82 per cent of the theoretical value. Although Pyrographite as a moderator could conceivably reduce the moderator volume by as much as 20 per cent, high cost and severe anisotropy will probably prohibit its use. As an impermeable coating for high temperature fuel and moderator blocks Pyrographite has definite possibilities if the price is suitable. The maximum thickness so far produced on a production basis is one half inch.

Fig. 3 Radioisotope fuelled electrical generator for satellites uses polonium 210 as heat source.

Two-Phase Heat Transfer in Liquid-Cooled Reactors

Heat transfer to two-phase vapour-liquid systems has been under study for a number of years in connection with the once-through (or Monotube) boiler, but a thorough investigation of the fundamental process has long been overdue. More recently, interest was renewed in two-phase heat transfer in connection with direct-cycle water reactors, nuclear superheating and other power station proposals which would use once-through steam raising units. An investigation at Harwell's chemical engineering division confirmed that heat transfer occurs in three distinct regions depending on the relative proportions of vapour to liquid. The effect of surface nucleate boiling governs heat transfer in the predominantly liquid phase, as a result of which the heat transfer rate is a function of heat flux. The mechanism changes when, through increased turbulence induced by the vaporisation process above 12 to 15 per cent quality, the liquid phase becomes a discontinuous suspension in vapour, and forced convection predominates. The region is characterised by rapid mass and hence heat exchange between the two phases and a "statistical" liquid film adhering to the vessel walls. Above 65 per cent quality the liquid phase becomes deficient and the heat transfer coefficient drops from a very high value for forced convection to a value comparable to heat transfer to dry gases. At constant heat flux the change in mechanism is accompanied by a sudden rise in surface temperature, indicating that tube burn-out is likely to occur in the liquid deficient region. (Heat Transfer to Two Phase Gas-Liquid Systems, Part 1. Steam Water Mixtures in the Liquid-Dispersed Region in an Annulus, by J. A. R. Bennett *et al.* AERE report R 3159.)

Direct Conversion Generator for Satellites

Direct conversion of radioactive energy to electricity is accomplished on a microscopic scale by a device developed by Martin Nuclear to power satellite instruments. Christened SNAP-3 for System of Nuclear Auxiliary Power, the first prototype has been in operation for over a year and is still producing a measureable amount of power in the order of a fraction of a watt. Fig. 3 shows the original prototype first demonstrated in January 1959 in the White House. Eight other models have since been built and subjected to an intensive testing programme which included operation in a vacuum at 100° below zero, vibration and impact tests, and accelerations up to 15 times the force of gravity. The heat produced by the radio-active decay of polonium 210 is converted to electricity by a series of thermocouples, so that no moving parts are employed. In future models a longer half-life isotope may be substituted for polonium 210 (half life 140 days) to prolong the useful life of the device. Conversely, the power output may be increased without affecting the generator's weight by substituting a more active radioisotope.

Mobile Training Laboratory for Isotope Handling

The International Atomic Energy Agency (IAEA) have acquired a second mobile laboratory for instruction in the handling of radioactive isotopes. Both mobile units now belonging to the IAEA have been donated by the United States Government, and the first unit has already served in Austria, Greece and Germany. In 1960 the two laboratories will operate in the Middle East and in Mexico and Argentina respectively.

Fast Critical Facility for Atomics International

In connection with the advanced epithermal thorium reactor programme of Atomics International (division of North American Aviation), an epithermal critical assembly will be built at the company's testing ground in Ventura County, California. The facility will be controlled by varying the approach distance of two subcritical halves of the reactor. Other work undertaken by Atomics International at the California testing grounds are an organic moderated and a sodium-graphite critical experiment.

Reactor Space for Hire

Battelle Memorial Institute, near Columbus, Ohio, is planning to lease reactor space for irradiation testing to private industry. It is believed that with a capital outlay of only $3,000 to $6,000 even small firms could undertake development of products requiring irradiation testing, a privilege previously reserved for public institutions and industrial giants who could afford to build their own reactor. The Battelle reactor, a light-water pool facility, can accommodate specimens up to 8 in diameter in six beam tubes, and in addition there are two openings into the graphite thermal column. The reactor is now operated at 2 MW and the Institute's staff have three years' experience in the handling of irradiation specimens.

Frontal Attack on Isotope Uses in USSR

To find further applications for radioactive isotopes the Latvian Institute of Physics has undertaken a survey of industries in preparation for widespread application of new techniques. A similar survey has been completed in Uzbekistan and is planned for other areas of the Soviet Union. Radiation inspection of sheet metal and the control of tin thickness on coated plates are already effecting considerable economies. For hospital sterilisation, an irradiation unit processes three tons of bandages per day continuously. A more esoteric application of irradiation reported in *Soviet Weekly* is curing vines of the disease *phylloxera* without affecting the quality of future crops.

The

'Engineering' Appointments

Section

RADIOLOGICAL AND INDUSTRIAL SAFETY SENIOR ENGINEER AND ENGINEER

are required by the

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

(PRODUCTION GROUP)

IN THE HEALTH AND SAFETY DEPARTMENT

AT SPRINGFIELDS WORKS, SALWICK, PRESTON, LANCASHIRE,

to be responsible to the Health Physics Manager for all engineering aspects of radiological and industrial safety.

The successful candidates will be expected to advise designers and plant management and to contribute to the overall safety assessment of chemical plant and laboratories handling radioactive materials.

A recognised engineering apprenticeship or comparable training, and corporate membership of a senior engineering institution or equivalent, are essential for both posts. Previous practical experience of industrial safety, together with knowledge of statutory safety requirements and experience of safety aspects of work with toxic materials, would be an advantage.

SALARY:

Senior Engineer — **£1880 to £2180** **(Ref. SF.13/12)**
Engineer — — **£1370 to £1825** **(Ref. SF.14/12)**
according to qualifications and experience in each case.

Staff Housing Scheme Contributory Superannuation.

Send postcard for application form, quoting appropriate reference, to Works Secretary at above address.

Closing date: 8th February, 1960. B 82

PUBLIC APPOINTMENTS

BRITISH RAILWAYS
WESTERN REGION

Applications are invited for STRUCTURAL DRAUGHTSMAN experienced in preparing estimates and contracts for the supply and erection of steel and concrete bridges, etc. Drawing Office and costing experience essential. Salary range £833/903.

Travel concessions, holidays with pay with prospects of promotion and permanency with membership of Superannuation Fund.

Applications stating age, previous experience, etc., to CHIEF CIVIL ENGINEER, B.R. WESTERN REGION, PADDINGTON STATION, LONDON, W.2. B 74

B.I.S.R.A.

YOUNG DESIGN ENGINEERS with a preference for original rather than conventional solutions of design problems, are invited to apply for positions in the Experimental Design Study Team of the British Iron and Steel Research Association in Sheffield. The team is engaged on problems of future steelworks plant development in collaboration with scientists engaged on advanced research into steel making and shaping processes and with development engineers of leading plant manufacturers.

Qualifications needed for the posts include:—engineering degree or H.N.C., experience in the design of special purpose machinery, special knowledge of either modern hydraulic systems or of electrical control systems.

Starting salary in the range of £900-£1100, with good prospects of advancement, Staff pension scheme. Canteen. Five-day week. Written applications only quoting "D.E.1" to the PERSONNEL OFFICER, THE BRITISH IRON AND STEEL RESEARCH ASSOC., 11, PARK LANE, LONDON, W.1. B 83

RESEARCH

THE BRITISH SHIPBUILDING RESEARCH ASSOCIATION has a vacancy in its Naval Architecture for a person with ability to initiate, lead and execute research. For this post the applicant should have an honours degree in naval architecture. The ceiling of salary is £1600 per annum and the commencing salary will depend upon age and qualifications. There are opportunities of promotion above this ceiling to a higher grade.

In addition to the investigations which the research staff themselves conduct, including work on board ships, they are also engaged upon progressing a programme of researches carried out under contract at outside laboratories, Government research establishments, Universities, etc. Members of the staff also deal with the technical secretarial work of the Association's system of research committees. All positions carry superannuation.

Applications with full particulars of education, apprenticeship, practical training and research experience should be addressed to B.S.R.A., 5, CHESTERFIELD GARDENS, CURZON STREET, LONDON, W.1. B 87

NEW ZEALAND
MINISTRY OF WORKS ENGINEERING STAFF

The New Zealand Ministry of Works invites applications for the following vacancies on the Permanent Staff. Positions, qualifications desired and salaries offered are as follow:—

Vacancy No. 1. CIVIL ENGINEERS. Corporate Membership of the Institution of Civil Engineers, London, together with sufficient appropriate experience. Commencing salaries up to £1525 per annum.

Vacancy No. 2. ASSISTANT CIVIL ENGINEERS. A University Degree in Civil Engineering, or Graduate Membership of the Institution of Civil Engineers, London, with at least five years of practical experience since commencement of pupilage. Commencing salaries £870 up to £1060 per annum.

Vacancy No. 3. MECHANICAL OR ELECTRICAL ENGINEERS. Corporate Membership of the Institutions of Mechanical or Electrical Engineers, London, together with sufficient appropriate experience. Commencing salaries up to £1525 per annum.

Vacancy No. 4. BUILDING SERVICES ENGINEERS. Corporate Membership of the Institution of Heating and Ventilating Engineers, London. Commencing salaries up to £1450 per annum.

Vacancy No. 5. ASSISTANT MECHANICAL OR ELECTRICAL ENGINEERS. A University Degree in Mechanical Engineering or Graduate Membership of the Institutions of Mechanical or Electrical Engineers, London, together with at least five years experience since commencement of pupilage. Commencing salaries £870 up to £1060 per annum.

Vacancy No. 6. ASSISTANT BUILDING SERVICES ENGINEERS. Graduate Membership of the Institution of Heating and Ventilating Engineers, London, with at least five years experience since commencement of pupilage. Commencing salaries £870 to £1060 per annum.

Civil Engineers and Assistant Engineers must have had experience in the design or construction of multi-storied reinforced concrete buildings or bridges and other structures. For the other vacancies experience is necessary in the design and installation of services or equipment for one or more of the following: heating and ventilating, air conditioning, hot and cold water or sewerage services, laundries, kitchens, boilerhouses, lifts and other mechanical services in offices, schools, hospitals, hotels, telephone exchanges, printing works, defence establishments, etc. All appointees will be required to undertake work of this nature.

APPLICANTS MUST BE RESIDENT IN THE UNITED KINGDOM OR EIRE AND HAVE FULFILLED NATIONAL SERVICE OBLIGATIONS.

Enquiries, mentioning this publication and stating the Vacancy Number and the position sought, should be addressed to the HIGH COMMISSIONER FOR NEW ZEALAND, 415 STRAND, LONDON, W.C.2. Full details of duties, experience required, general information on the conditions of employment in the New Zealand Public Service and application forms will then be supplied. A 980

BRITISH TRANSPORT DOCKS

invite applications for the position of

ASSISTANT ENGINEER (Mechanical)

in the Chief Docks Engineer's Office, Hull Docks.

Applicants should preferably have had experience in docks mechanical engineering including all types of appliances and machinery. Corporate Membership of the Institution of Mechanical Engineers essential. Salary range £1315-£1590 per annum. Contributory superannuation scheme and certain rail travel facilities.

Applications, giving age, education, training, experience and qualifications to:

STAFF AND ESTABLISHMENT OFFICER,
BRITISH TRANSPORT DOCKS (E),
163, EUSTON ROAD, LONDON, N.W.1,

to arrive not later than Friday, 29th January, 1960. B 108

DEVELOPMENT ENGINEER

age 22 to 27 years

A SCIENCE GRADUATE, preferably in Mechanical Engineering, is required to assist the Project Manager of our Rubber Division in the development of mechanical rubber, plastic and textile products. An honours degree would be an advantage but the main requirement is a sound knowledge of fundamental principles and ability to apply them in a practical manner.

This new position provides a very good opportunity for training, development experience and early advancement in a progressive firm for a man who gets on well with people at all levels. A good salary will be offered to attract both men who recently graduated and graduate engineers who have completed two years' practical training. Salaries are reviewed annually, the position is superannuated and housing assistance is available.

Further details will be given to applicants who submit details of qualifications and experience—previous experience of technical development work is desirable but not essential. Please write to:

Group Appointments Officer,
GEORGE ANGUS AND COMPANY LIMITED,
Angus House, Westgate Road,
Newcastle upon Tyne, 1.

B 106

DOWTY HYDRAULIC UNITS LIMITED,

Ashchurch, Glos. (Industrial Division) require a

PUMP DESIGNER

for the design of gear and piston pumps.

A minimum qualification of H.N.C. with wide experience in the field of industrial hydraulics is essential.

The successful candidate will enjoy excellent working conditions in an expanding organisation, including facilities for the extensive development of original thought.

A lodging allowance, assistance with removal expenses, and a contributory pension and life assurance are among the fringe benefits attached to this appointment.

Apply confidentially to the Personnel Manager. B 78

PHYSICIST ENGINEER

Applications are invited from Physicists with practical engineering experience, Min.A. Level for an interesting appointment in a new departure in the Nuclear Engineering field with particular reference to Irradiation problems.

Applicants will be given an extensive course of training before taking up a responsible position in the North West. All applications will be treated in confidence and should be addressed to BOX B 123, Offices of ENGINEERING.

AIR MINISTRY

AIR MINISTRY Works Designs Branch requires in LONDON—STRUCTURAL ENGINEERING DESIGNER DRAUGHTSMEN for reinforced concrete or structural steelwork of all types. Applicants must have adequate training and several years' experience. Some site experience and possession of recognised technical qualification an advantage. Financial assistance and time off may be allowed for recognised courses of study. Promotion and pension prospects. Five-day week with 18 working days leave per year initially.

Salary for Grade III ranges from £680 (at age 25) to £900 p.a. Commencing salary dependent on age, qualifications and experience. Also vacancies in higher grade for suitably qualified candidates on range from £895 to £1055 p.a. Applicants, who must be natural born British subjects, should write to AIR MINISTRY, W.C.1., LACON HOUSE, THEOBALDS ROAD, LONDON, W.C.1, or to any Employment Exchange (quoting Order No. Kings Cross 3745) giving age, details of training, qualifications, full particulars of former posts held and copies of any testimonials. Candidates selected will normally be interviewed in London and certain expenses reimbursed. G 842

DRAUGHTSMAN

Applications are invited for the above post, which is located in Birmingham.

The work is interesting and varied and is mainly in connection with the design of industrial heating equipment. A knowledge of combustion technique and the use of refractories would, therefore, be an advantage.

Candidates should possess the Ordinary National Certificate in Mechanical Engineering as a minimum qualification.

The salary for the appointment, which is pensionable and subject to medical examination, will be within the range of £733-£853 per annum.

Applications, stating age, qualifications and experience, together with the names of two referees, should be addressed to the INDUSTRIAL RELATIONS OFFICER, WEST MIDLANDS GAS BOARD, 6, AUGUSTUS ROAD, EDGBASTON, BIRMINGHAM, 15. G 841

ASSISTANTS (SCIENTIFIC)

Pensionable posts for men or women at least 17½ and normally under 26 on 1.1.60 with appropriate education or technical qualifications (normally G.E.C. with passes at "O" or "A" level in 4 distinct subjects including English Language and a scientific or mathematical subject, or O.N.C., or equivalent qualifications) and at least 2 years' experience in either: (i) engineering or physical sciences, or (ii) chemistry, bio-chemistry or metallurgy, or (iii) biological sciences, or (iv) geology, meteorology, or skilled work in laboratory crafts such as glass-blowing. Starting salary (men, London) from £347 10s. (at 17½) to £550 (at 25 or over). Maximum (London) £715. Promotion prospects. Five-day week generally.—Write CIVIL SERVICE COMMISSION, 17, NORTH AUDLEY STREET, LONDON, W.1, for application form, quoting 859/60. B 102

LONDON COUNTY COUNCIL

ROBERT BLAIR FELLOWSHIP IN APPLIED SCIENCE AND TECHNOLOGY

Applications are invited for the award of the Robert Blair Fellowship tenable for one year of advanced study or research abroad in applied science and technology. The value of the award is subject to variation, and, if the country selected should be Canada or the U.S.A., may be up to £2000 (subject to income tax).

Candidates must be British subjects and at least 21 years of age.

Further particulars and forms of application may be obtained from the EDUCATION OFFICER (ED/MA/14), THE COUNTY HALL, S.E.1 (stamped addressed foolscap envelopes necessary) for return by 12th March, 1960. (75) B 100

COUNTY BOROUGH OF BURTON UPON TRENT EDUCATION COMMITTEE

TECHNICAL COLLEGE

Principal: E. WHITE, M.Sc.

Applications are invited for the following posts, which are available due to expansion. Salary will be in accordance with the Burnham Technical Scale. Forms of Application, which may be obtained from the undersigned upon receipt of a stamped, addressed foolscap envelope, should be sent as soon as possible to the Principal, the Technical College, Burton Upon Trent, from whom further particulars may be obtained.

ENGINEERING DEPARTMENT

1. Mathematics (Grade B). Graduate required, willing to teach at all levels up to H.N.C.
2. Welding and Fabrication of Steelwork (Grade A).
3. Engineering Workshop Practice and/or Metalwork (Grade A).

A. H. BLAKE,
DIRECTOR OF EDUCATION.

EDUCATION OFFICE,
GUILD STREET,
BURTON UPON TRENT. B 95

SENIOR SCIENTIFIC OFFICERS (*a*): SCIENTIFIC OFFICERS (*b*)

Pensionable posts for men and women in all major scientific fields, including physics, chemistry, biology, meteorology, mathematics. Specially needed are:—

CHEMISTS for research in reaction kinetics.
BOTANIST for study of bryophyta.
PHYSICIST/RADIO BIOLOGIST (Fisheries).
PHYSICISTS/ELECTRICAL ENGINEERS for research in the application of servo-control for machine tools.

Qualifications: normally first or second class honours degree in science, mathematics or engineering, or equivalent attainment; additionally, for (*a*) at least 3 years' relevant (e.g. post-graduate) experience. Normal age limits: (*a*) between 26 and 32, (*b*) between 21 and 29, with extension for regular Forces Service and Overseas Civil Service. London salaries (men): (*a*) £1233-£1460, (*b*) £655-£1150; provision for starting pay above minimum. Promotion prospects. Write CIVIL SERVICE COMMISSION, 17, NORTH AUDLEY STREET, LONDON, W.1, for application form, quoting (*a*) 853/60, (*b*) 852/60. B 101

PRINCIPAL SCIENTIFIC OFFICER:

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH. Pensionable post for man or woman to serve initially for about 3 years at the Shirley Institute of the British Cotton Industry Research Association, Manchester, for work on development of automatic spinning plant for the conversion of natural and synthetic fibres into yarn; and subsequently at the National Engineering Laboratory, East Kilbride, for research in the field of mechanical engineering. Housing will be available at East Kilbride for married staff. Qualifications: normally 1st or 2nd class honours degree in mechanical engineering or high professional attainment. Experience of the application of automatic control systems and mechanical handling and transfer equipment essential, and a broad engineering background desirable. Knowledge of the textile industry is not essential. Men's salary scale £1460-£2070. Starting pay may be above minimum. Promotion prospects.—Write CIVIL SERVICE COMMISSION, 17, NORTH AUDLEY STREET, LONDON, W.1, for application form, quoting 85088/60. Closing date 11th February, 1960. B 77

PROCESS PIPING SYSTEM ENGINEERS

Chemical or Mechanical Engineers are required for work on the design of process and utility piping systems for oil refinery and petro-chemical plants. The work involves the preparation of engineering flow diagrams and close liaison with our Process, Instrument, Mechanical Equipment, Plant Layout and Operating groups.

Applicants should have a University Degree in either Chemical or Mechanical Engineering and also at least two years' relevant post-graduate experience in industry.

Above average salaries will be paid to men with the required qualifications. Comprehensive personnel benefits include contributory Pension Scheme, Luncheon Vouchers, excellent working conditions, Social Club, etc. When overtime is worked, payment is made for hours involved.

Please apply by letter to Personnel Manager

KELLOGG INTERNATIONAL CORPORATION

7-10, CHANDOS STREET · CAVENDISH SQUARE · LONDON, W. 1. · QUOTING REFERENCE H/152

B 111

THE UNIVERSITY OF SHEFFIELD

Applications are invited for a post of RESEARCH ASSISTANT in the POSTGRADUATE DEPARTMENT OF APPLIED MECHANICS to begin duties as soon as possible. Salary in the range £650-750 according to qualifications and experience, and F.S.S.U. provision and family allowance. A grant towards removal expenses will be made.—Further particulars may be obtained from the REGISTRAR to whom applications (4 copies) should be sent by 13th February, 1960. B 76

RESEARCH AND DEVELOPMENT ENGINEER

required
for work on the
COMBUSTION OF LIQUID FUELS

This position offers the successful candidate outstanding opportunities to carry out work, from fundamental research to commercial development, in the field of oil burning, in the newly formed Research Department of one of the pioneer companies of this Industry.

Applicants should have a degree in Mechanical Engineering or equivalent qualifications. Experience either in combustion or aerodynamics is desirable but consideration will be given to candidates without this experience who are otherwise suitable.

The Company operates a contributory superannuation fund and a life assurance scheme.

Applications which will be treated in strict confidence, should include details of age, education, experience and salary required, and be addressed to BOX B 107, Offices of ENGINEERING.

BECHUANALAND PROTECTORATE
ENGINEER (MECHANICAL), PUBLIC WORKS DEPARTMENT

To assist the Senior Engineer (Mechanical) in the running of the Government Workshops, transport and mechanical equipment.

Permanent or contract/gratuity appointment. Salary in range £928-£1848. Rented quarters. Free passages. Children's education allowance.

Candidates must be A.M.I.Mech.E. or possess B.Sc. in mechanical engineering with at least 5 years' relevant experience.

Write DIRECTOR OF RECRUITMENT, COLONIAL OFFICE, LONDON, S.W.1, giving full names, age, qualifications and experience, quoting BCD 112/76/013/D5. B 117

CITY OF BIRMINGHAM
EDUCATION COMMITTEE
HALL GREEN TECHNICAL COLLEGE, STRATFORD ROAD, BIRMINGHAM, 28

Principal-Designate: G. H. PALMER, M.Sc., A.Inst.P.

Applications are invited for the post of HEAD OF THE ENGINEERING DEPARTMENT (Grade II) to take up duties on 1st September, 1960.

The College is now being built and will open in September, 1960. The Department will be mainly concerned with Mechanical Engineering Courses to Ordinary National Certificate standard, Machine Shop Engineering and similar courses, and Motor Vehicle work for which the College is specially equipped. There will be Electrical Installation and possibly other Electrical Courses.

Applicants should be graduates, preferably in Mechanical Engineering, with good teaching and industrial experience. It is hoped to appoint a man with energy and initiative to develop the work of the new Department.

Salary: (Burnham Report, 1959) £1600 by £50 to £1800 per annum.

In certain circumstances it may be possible to offer a starting salary above the minimum of this scale. Application forms and further particulars of the post may be obtained from the Principal-Designate, present address — MATTHEW BOULTON TECHNICAL COLLEGE, SUFFOLK STREET, BIRMINGHAM, 1. Completed forms should be returned to him not later than 15th February.

E. L. RUSSELL,
CHIEF EDUCATION OFFICER. B 116

COUNTY BOROUGH OF
BRIGHTON EDUCATION COMMITTEE
BRIGHTON TECHNICAL COLLEGE

Required as soon as possible:—
ASSISTANT LECTURER (GRADE B) IN Mechanical Engineering. Degree in Engineering, A.M.I.Mech.E., or equivalent, essential. Teaching experience is desirable.

Salary Scale:—£700 by 27½ (15) + 37½ to £1150 (men) plus graduate and training allowances and with increments for approved research, professional or industrial experience.

Further particulars and forms of application from the undersigned, to be returned to the Principal, Brighton Technical College, Brighton, 7, within 14 days.

W. G. STONE,
DIRECTOR OF EDUCATION.
54, OLD STEINE,
BRIGHTON. B 113

APPOINTMENTS OPEN

ENGINEERS AND DRAUGHTSMEN

CONSULTING ENGINEERS urgently require additional staff in London and Darlington, engineers and draughtsmen for both reinforced concrete and steelwork.—Full particulars to F. R. BULLEN & PARTNERS, DACRE HOUSE, DEAN FARRAR STREET, S.W.1. A 981

GRADUATE MECHANICAL ENGINEERS AND METALLURGISTS
THE BAHRAIN PETROLEUM COMPANY LIMITED

part of the world-wide

CALTEX GROUP OF COMPANIES

marketing petroleum products in the UNITED KINGDOM through the REGENT OIL COMPANY LIMITED require GRADUATE MECHANICAL ENGINEERS and METALLURGISTS for process plant inspection and corrosion and materials engineering in Bahrain's modern oil refinery.

Duties will include inspection of all types of petroleum processing equipment; power plant boilers and auxiliaries; oil storage and distribution equipment; utilities; wharves, jetties and causeways; marine vessels; bridges; and oil field equipment. The work requires knowledge of ASME, API, TEMA and BS codes for the construction of pressurised equipment, design methods, maintenance engineering, materials of construction, process design, corrosion engineering and cost analysis. Men with metallurgical backgrounds would have opportunities to enter fully equipped laboratories to specialise in materials or corrosion engineering.

Technical men with or without experience will do well to consider a career in this branch of engineering. The work presents unrivalled opportunities to gain wide experience quickly with excellent prospects of promotion to senior posts in the oil industry.

Salary would be generous in accordance with qualifications and experience and free air-conditioned accommodation and a living allowance would be provided. An initial kit allowance, free medical attention and paid local and home leaves are also provided with participation in Pension and Provident Fund Schemes.

Apply in writing, quoting "INS" with details of qualifications and experience to CALTEX SERVICES LIMITED, CALTEX HOUSE, KNIGHTSBRIDGE GREEN, LONDON, S.W.1.

B 112

AUTOMOTIVE ENGINEERS

MAJOR PETROLEUM COMPANY has vacancies for qualified AUTOMOTIVE ENGINEERS as TECHNICAL SALES REPRESENTATIVES in the North of England. Candidates should be between 25 and 35 years of age, must be Associate Members or Graduates of the Institution of Mechanical Engineers, dependent on age, and have served with a Commercial Vehicle Manufacturer. They must possess a sound knowledge of C.I. Engines and of all types of final drive, and have some Service Department and possibly Sales experience. Starting salary commensurate with qualifications and experience, excellent conditions of employment and plenty of scope for men of above average intelligence and personality.—Apply giving full details of age, qualifications and experience to BOX B 84, Offices of ENGINEERING. Replies can only be sent to those selected for interview.

MEN WITH H. & V. OR ELECTRICAL EXPERIENCE

Westminster engineers wish to recruit men with H. & V. or Electrical Contracting experience in the salary grades of £1500-£1000-£750 to increase Drawing O. capacity. In addition to a Senior appointment requiring ability to lead Department in direct association with responsible Partner, vacancies exist for Intermediate and Junior grade Draughtsmen with suitable qualifications and ability. All posts offer good prospects for promotion in expanding firm. Own Staff informed.—Apply in writing to BOX B 81, Offices of ENGINEERING.

INTERMEDIATE DRAUGHTSMAN

Intermediate Draughtsman wanted for design and development work on portable pneumatic and electric tools. N.W. London.—Write in first instance giving age, experience and salary required to Chief Designer, BOX B 96, Offices of ENGINEERING.

THE MANCHESTER SHIP CANAL COMPANY

The Manchester Ship Canal Company invite applications for the appointment of ASSISTANT CIVIL ENGINEERS AND DESIGN ENGINEERS on the established staff of the Chief Engineer. Scale of salaries: £805 at age 25, rising by annual increments to £1250 at 38 with prospects of promotion to higher grades at salaries up to £1720.

Candidates should be Corporate Members of the Institution of Civil Engineers or hold equivalent qualifications, and should have experience in design, specifications, construction and maintenance of Civil Engineering works. Harbour and dock experience is preferable but not essential.

Successful applicants will require to become members of the Company's Contributory Superannuation Scheme.

Applications, stating age, qualifications and experience, should be addressed to the Chief Engineer, THE MANCHESTER SHIP CANAL COMPANY, SHIP CANAL HOUSE, KING STREET, MANCHESTER, 2, not later than 13th February, 1960. B 90

MEN WITH AMBITION

Applications are invited from those with ambition to join expanding sales organisation. Successful applicant, who will be paid salary and expenses, will be required to operate from LEEDS and will be responsible direct to Principal. Must have sound engineering background and possess current driving licence. Age 30-40.—BOX B 28, Offices of ENGINEERING.

BRITISH TRANSPORT COMMISSION

British Transport Commission invites applications for the following post:—RESEARCH STATION, DOCKS AND WATERWAYS, HAYES ROAD, SOUTHALL.

SCIENTIFIC OFFICER

Salary Range £1,045 — £1,150

Candidates should have good degree in Physics or Engineering with mathematical ability and knowledge of hydraulics. Practical experience in research or engineering an advantage.

Superannuation scheme. Certain travel facilities. Medical examination. Write stating age, qualifications and experience to:—

DIRECTOR OF ESTABLISHMENT,
BRITISH TRANSPORT COMMISSION,
222, MARYLEBONE ROAD, LONDON, N.W.1

within 7 days. B 109

A well established and expanding Company in the North East invites applications from Engineers for the following posts:

(a) CHIEF DESIGN ENGINEER
(b) CHIEF ESTIMATING ENGINEER
(c) PURCHASING ENGINEER

For each appointment, the main requirements will be an appropriate engineering qualification and experience principally in coded vessel fabrication, heat exchangers, tubular structures and pipeline work. The chosen applicants will control, in their respective fields, sections in the categories named and in several subsidiary lines of engineering activity.

The appointments will be top level carrying salaries commensurate with their responsibilities and superannuated; the chosen applicants will be men with ideas and initiative, the ability to control staffs and the ambition to make progress. The preferred age range is 35 to 45.

Applications in confidence, giving fullest details to BOX B 85, Offices of ENGINEERING.

WILMOT BREEDEN FELLOWSHIP

Applications are invited for a FELLOWSHIP to be held in association with the College of Advanced Technology, Birmingham. The value of the Fellowship, which is for a two-year term, is £1000 per annum.

A candidate for the Fellowship should normally have had two or three years' research or industrial experience. He should have an honours degree or equivalent qualification and be acceptable to the College of Advanced Technology as a research fellow.

The Wilmot Breeden Fellow would engage in an enterprise of such a character as to require the facilities both of the College and the Company, his time being spent at both. His enterprise may have the character of Scientific Research, Design, Development, a combination of some or all of these, or in some other way to be appropriate to the activities of Wilmot Breeden. The Company is especially concerned with Mechanisms, Electro-Chemistry, Metal Finishing, Metallurgy, Metal Formation, Hydraulics, Electronics.

Full details may be obtained on application to—MR. F. SARGEANT, SECRETARY, WILMOT BREEDEN FELLOWSHIP COMMITTEE, AMINGTON ROAD, BIRMINGHAM, 25.

Final applications must be received by the Secretary before 1st May, 1960. B 29

THE BAHRAIN PETROLEUM COMPANY LIMITED

require a

MAINTENANCE ENGINEER

This post is open to recent graduates in Mechanical Engineering, under 28 years of age, who are interested in all phases of planned maintenance of heavy plant and who have preferably some experience on pressure vessel, heat exchanger and pump repair or construction. It is intended that the selected candidate should train in Bahrain with a view to advancement to at least Area Engineer in the large and modern refinery there.

A good salary can be offered dependent upon qualifications, in addition to which free air-conditioned accommodation and a living allowance are provided. An initial kit allowance, medical attention, paid house and local leaves (passage paid for the former and generous assistance towards the latter) are also provided, with participation in the Company's Pension and Provident Fund Schemes.

Apply in writing, quoting "MTC," with full particulars to: CALTEX SERVICES LIMITED, CALTEX HOUSE, KNIGHTSBRIDGE GREEN, LONDON, S.W.1. B 94

SALES DEVELOPMENT EXECUTIVE
SALES ENGINEER

A well known and old established company, specialising in manufacture of equipment for air treatment and purification seeks a Sales Development Executive and four Sales Engineers for appointments based on London and Manchester.

The Company is being reorganised to allow for considerable expansion and these appointments are part of a scheme to ensure high product efficiency.

The Sales Development Executive will carry out market research to establish outlets for the company's expertise in a widening industrial field.

The duties of the Sales Engineers will be comparable to those normally carried out by Technical representatives.

All applicants must be sound engineers of at least H.N.C. standard, under 40 years of age, with experience as technical salesmen in the capital goods market. Starting emoluments £1500/£1250 with good prospects of higher remuneration after the first year.

Write briefly in strictest confidence.

The Managing Director (RM.53),

EXECUTIVE APPOINTMENTS LIMITED,

78 Wigmore Street, London, W.1.

B 127

COMPUTER CONTROLLED PROFILING MACHINES

INSTALLATION AND MAINTENANCE

TWO ENGINEERS

are required for work on the installation and subsequent servicing of tape controlled automatic profiling machines. Candidates should have the H.N.C. or equivalent qualification in Electrical Engineering and have experience of electro-mechanical and electronic devices and control systems. Experience of servicing light current electrical installations may be an advantage.

A period of training will be given prior to the machine installations, and for the first twelve months thereafter, one engineer will be resident on the N.E. Coast and one in the N.W. Lancashire area.

Applicants, who should be at least 30 years of age, will be offered a good commencing salary and they should be earning not less than £1000 per annum in their present employment. A contributory pension scheme is in operation.

Please reply stating full particulars to the:

PERSONNEL MANAGER,

BRITISH OXYGEN GASES LIMITED,

SPENCER HOUSE,

ST. JAMES'S PLACE, S.W.1. B 115

PRODUCTION DEVELOPMENT

STAFF REQUIRED

for interesting new projects covering the following branches of Production Engineering:—

PLANNING AND TOOL DESIGN for machined parts.

PLANNING AND TOOL DESIGN for major assemblies and plate details.

PLANNING of Aircraft **ELECTRICAL INSTALLATIONS.**

Men with experience of one or more of the above are also required to work in conjunction with Aircraft Designers to advise on ways of achieving the best design of component for production.

DESIGN OF TOOLS and special machines for manufacture of components for **ATOMIC ENERGY PROJECTS.**

CUTTING TOOL DEVELOPMENT involving advanced techniques on light alloy and ultra high tensile steels, etc.

Applications from suitably experienced candidates should be sent to the PERSONNEL OFFICER, FAIREY AVIATION LIMITED, HAYES, MIDDLESEX. B 16

BRITISH RAILWAYS
LONDON MIDLAND REGION
require a
STRUCTURAL ENGINEER

at Euston to undertake design in steel, reinforced and pre-stressed concrete, capable of calculating statically indeterminate structures. Must have a University degree and experience in similar work. Post Graduate studies and membership of the Institution of Civil Engineers of the Institution of Structural Engineers will be an advantage.

Salary range £1150 to £1315 per annum. Superannuation Scheme, five-day week, residential and other travelling facilities.

Applications quoting reference 90 and giving details of age, educational qualifications and experience to:—CHIEF CIVIL ENGINEER, BRITISH RAILWAYS, LONDON MIDLAND REGION, 5A, EUSTON GROVE, LONDON, N.W.1. B 88

DRAUGHTSMEN

Versatile Engineering Draughtsmen with general experience are required by a Plastics Manufacturing Company employing approximately 2000, with Engineering Department of 400. The work involved includes machinery design and layout, etc., and is of considerable interest. O.N.C. or H.N.C. desirable. A.E.S.D. rates and above. Good transport facilities and working conditions. Contributory Life Assurance/Pension Scheme.

Apply, giving details of training, qualifications, experience, age and career to date, to:—

PERSONNEL MANAGER,
BX PLASTICS, LTD.,
BRANTHAM WORKS,
NR. MANNINGTREE, ESSEX.

B 104

YOUNG ENGINEERS

Young engineers, with practical or design experience, who seek an opportunity to sell technical products to engineers, will be trained to sell and offered a career by leading London company.—Fullest particulars of education, experience and ambition, to BOX B 97, Offices of ENGINEERING.

QUALIFIED ELECTRICAL ENGINEER

A vacancy exists for a qualified electrical engineer with an Hydro-Electric Power undertaking in Northern Nigeria. Pleasant climate 4,000 ft. above sea level. Age 30 to 35. Salary grade £1335/1565 according to age, qualification and experience. Pension and Life Assurance Scheme. Eighteen months tours with three months' leave on full salary. Free furnished quarters. Free passages self, wife and two children, or equivalent benefits if children remain at home.—Write BOX D401, c/o STREET'S, 110, OLD BROAD STREET, E.C.2. B 86

ENGINEERING DRAUGHTSMAN

ENGINEERING DRAUGHTSMAN, experienced in all aspects of services layout. Work in connection with the modernisation and replacement of services equipment in a large Institution. Duties entail thorough knowledge of steam, hot water, air distribution and associated equipment. Salary will depend on experience and qualifications, but it is expected to be in the range £750-£1000 p.a.

Applications, giving details of training, experience and qualifications to BOX No. 3133, c/o CHARLES BARKER & SON, LIMITED, GATEWAY HOUSE, E.C.4. B 105

HEAT TRANSFER ENGINEER

HEAT TRANSFER ENGINEER. A.M.I.Mech.E. or H.N.C., for work on Extended Surface and Plain Tube Heat Exchangers Factory in West Sussex. Prospects excellent in rapidly developing company. Must be willing to travel.—BOX B 119 Offices of ENGINEERING.

WORKS MANAGER

An interesting and responsible post is available in a rapidly expanding Company engaged in the manufacture of Accessories for the Motor Industry and situated in the London area. Applications are invited from qualified persons age 30/50 who have had extensive Machine Shop, Tool Room and Production experience.

Ability to handle a large labour force and experience in negotiating with Trade Unions is of prime importance. The prospects are good.

Preference will be given to those with A.M.I.Mech.E. and A.M.I.P.E. or equivalent qualifications. The appointment arises because of retirement and offers a commencing salary of up to £2000 per annum for a suitable man.

Applications covering career history to date and other relevant details should be addressed in strict confidence quoting ref. A.H. to BOX B 114, Offices of ENGINEERING.

DRAUGHTSMAN

DRAUGHTSMAN required for work on Valve Design; all applications will be treated in confidence. —Apply in writing to CHIEF ENGINEER, ALLEY & MACLELLAN, LTD., BROMYARD ROAD, WORCESTER. B 122

STEEL WORKS PROJECT ENGINEER

An opening offering good prospects is available for a man of proved ability qualified in the layout and operation of Steel Works Plant and the co-ordination of requirements for Heavy Shears, Handling Equipment and Ancillary Gear, etc.

Applicants should be able to guide general designs to meet specifications and supervise the manufacture and building of complete equipments.

In the first instance please give full details of age, training and experience.

Write BOX B 121, Offices of ENGINEERING.

ADVERTISEMENT RATES

'Engineering'
Appointments Section

CLASSIFICATIONS: Public Appointments, Appointments Open, Appointments Wanted.

TYPES OF ADVERTISEMENTS:

(a) "Appointments Illustrated" and illustrated careers advertisements: photographs or drawings may be used in conjunction with type matter.

Rates: per page (12 in. by 9 in.) ..	£100
per half page	£54
per quarter page	£29

(b) Semi-display: type matter, with or without surrounding rule, name block or symbol.

Rates: per page (12 in. by 9 in.) ..	£100
per half page	£54
per quarter page	£29
per single column inch ..	£2 14s.

c) Single column "run-on" advertisements: approximately 6 words to the line, 12 lines to the inch.

Rate per line	4s. 6d
(Minimum charge 18s.)	

SERIES DISCOUNTS: 5 per cent. on 6 insertions; 10 per cent. on 13; 15 per cent. on 26.

BOX NUMBER: 2s.

Company Meetings

Quarter page £29 : half page £54 : full page £100

COPY DATE: First post Monday.

BLOCKS: To be mounted ready for printing Screen 100.

ORDERS TO: "Engineering," 36, Bedford Street, London, W.C.2 Telephone TEMple Bar 3663

Companies

Vickers, Bristol and English Electric

In less than three months from pulling up his chair to the Minister of Aviation's desk, Mr. Duncan Sandys, who wanted just two big airframe groups in the aviation industry, has seen precisely that happen.

The BRISTOL AIRCRAFT, VICKERS-ARMSTRONGS (AIRCRAFT) and ENGLISH ELECTRIC AVIATION group has the blessing of the Minister. Mr. Sandys has said that he would regard the new company as qualifying for Government support.

The getting together of HAWKER SIDDELEY, BLACKBURN and DE HAVILLANDS and of the three in the second airframe group amounts to a setting of the scene for the decisive 1960's, and the statement on future Government help is the first useful pointer to the future. Decisions on who is to be helped to do what may be much closer than is generally thought.

If the DH121, by the AIRCO team, is to have a future it has to be pushed ahead rapidly. What is happening to the Airco group is that de Havilland have merged with Hawker, HUNTING AIRCRAFT are widely expected to join the Vickers group, and FAIREY AVIATION, which has wide interests other than in aviation, stays out on its own. So far BRITISH EUROPEAN AIRWAYS have expressed interest in the DH121 medium and short range four jet airliner but the Vickers VC11 is a rather larger plane. The VC11 is intended for ranges up to 3,000 miles while the DH121 is not meant for stages of more than 1,500 miles.

BEA may prefer the DH121, which should have excellent runway performance, and the difference in range may be academic to them, but sales to more than one airline would be needed for a profitable operation and other operators of any size, outside the United States, might well prefer the longer range model. Both groups are of a size, both in men and money, to have no wish to remain dependent on the swings and roundabouts of defence policy. But guided missiles are of importance in assessing the future fortunes of the two groups. Both groups have promising development going on within their member companies, although Hawker-de Havilland have both Blue Streak and Black Knight, and outside the two big brothers, there is Fairey Aviation to be considered as the producer of some well-tried rockets. The export market for guided missiles is sharply competitive and inevitably overshadowed by the American lead in the really big numbers.

At home, this sort of production, while an integral part of modern defence arrangements, remains at the mercy of switches in the political climate and decisions by the defence departments.

Helicopter Policies

Future uncertainties for the aircraft industry and the high cost of research and development have led Mr. Eric Mensforth, chairman of WESTLAND AIRCRAFT, the helicopter group, to put aside £1,000,000 out of last year's profits against the time when profits may not be enough to cover the group's development.

This cautious approach to the future is one side of the company's policy. The other is the confident way in which Westland is going ahead entirely on its own resources developing the Westminster helicopter, powered with twin Eland turbines. The first production Westminster is to be flying by mid-April, 1961. Large sums are being tied up in the machine. Mr. Mensforth says the company does not underestimate the risk involved or the possibility that no future return may come of it.

As the largest helicopter manufacturers in Europe, Westland do not long stay out of the news. In the recent get-togethers in the air industry the group took the first steps for the buying of the BRISTOL COMPANY'S helicopter interests. The aviation and allied interests of SAUNDERS-ROE had been bought last August so that Westland are responsible for the development of the Hovercraft.

Mr. Mensforth makes the point in his annual statement that if there were any danger of monopoly in this country it would be corrected by well established competition abroad. A recent sharp example of this was the sale to an Austrian-Swiss hotel combine of a Soviet Mi-4 helicopter, with crew training and spares.

In addition to the Westminster, Westland have a number of other interesting helicopters in development or production. They begin with the lightweight Rotorcycle, a single-seat helicopter. A number are being made for the HILLER AIRCRAFT CORPORATION, of the United States. At the other end of the weight scale is the Wiltshire, a boat-hulled helicopter with twin Gazelle turbines, later it is to have three, to carry up to 23 passengers, and it should be flying some time this year.

Westland have an association with the distinguished American helicopter firm SIKORSKY.

Excellent Prospects For SCoW

Since the STEEL COMPANY OF WALES starts its current financial year with increased production capacity and a full order book, the chairman, Mr. Harald Peake, may well say the company's prospects are very good.

The steel companies' problems are not those of selling steel sheet but of making sufficient for home orders, and if they could do that to go on to meet some of the exhortations of successive Chancellors of the Exchequer to expand in the export markets.

The United States steel strike brought urgent inquiries to SCoW for supplies to help out. Because of the strong demand at home no deliveries were made apart from normal supplies of tinplate. In the tinplate market there had been a fall in the world price level but more recently there has been a measure of improvement in prices.

Despite the interruption of steel making in November, 1958, when the original slabbing mill was replaced with a new universal mill in the unusually short time of 12½ days, production of steel ingots reached the record level of 2,324,000 tons in the year. Tinplate production was also a record, at 802,000 tons, passing the previous highest figure of just over 700,000 tons in 1957. Exports of tinplate and sheets, including special electrical sheets, rose from £27,407,000 in the previous year to £32,251,000.

For this year Mr. Harald Peake forecasts in his annual statement that an annual rate of 3,000,000 tons of steel ingot production should be reached by the year's end. For the longer future Mr. Peake observed that for all the heavy capital expenditure there is still an acute shortage at home of rolled steel and tinplate products. If the world is, as there appear to be signs, entering a period of peace and increased standards of living, a world shortage of tinplate and steel sheets appears likely to continue for some years.

South Durham's Great New Works

The amount of invested capital required by the steel industry to do its job is as great as any other industry's in the

world. Just what this means, and not only to the shareholders, was carefully spelt out by the chairman of the SOUTH DURHAM STEEL & IRON company, Mr. Benjamin Chetwynd Talbot (inset), in his recent annual statement.

South Durham Steel & Iron are well up to schedule in the creation on a 530 acre site at Greatham, West Hartlepool, of a £49 million heavy and medium steel plate mill which Mr. Talbot says will be the most modern and efficient of its type in the world. Up to October last year almost £23 million had been spent on the new works. Ingot production from what is called the South Works, and the rolling of plates up to 136 in wide is due to begin by November of this year. In another nine months after that the South Works should be completed and up to its full capacity of 1 million tons of plates a year. The slabbing mill, made by the UNITED ENGINEERING & FOUNDRY COMPANY of Pittsburg, USA, was completed ahead of the contract date.

Mr. Talbot, observing that he did not intend to shake the confidence of existing or future shareholders in the company, set out the directors' reasons for not increasing the final dividend. The reasons he gave are highly significant for manufacturing industry.

As the work on the South Works progresses there will be a substantial increase in the interest to be paid on the loans from Barclays Bank and the Finance Corporation for Industry. There will also be a further increase in the depreciation charge on plant.

Of demand for the company's products Mr. Talbot spoke early in his report of an increase since the end of the financial year but later he reported: "the dearth of inquiries at present circulating is giving concern."

The company's steel pipe, fabricating and constructional departments, at Stockton on Tees, worked at high production levels throughout the year. Part of this activity was in fulfilment of IRAQ PETROLEUM company orders and also the completion of an order from YACIMIENTOS PETROLEUM company for 58,500 tons of 24 in diameter steel pipes for use in the Argentine. Production has also begun on a SHELL INTERNATIONAL PETROLEUM company order for Indonesia and on another for the BRITISH COLUMBIA ELECTRIC company for Vancouver.

Until and unless a recovery sets in for the shipping order books, and until the BRITISH TRANSPORT COMMISSION can speed up its investment in the modernisation plan the demand for South Durham's plates and rails is bound to remain under something of a cloud. The reduction in demand from the NATIONAL COAL BOARD is likely to continue unless an unexpected change overtakes the power situation in the next few years. In oil, where, as the chairman observes, the oil companies found demand expanding by 3 per cent a year and not the 7½ they had forecast, it is possible that the demand for pipes may increase if a settled pattern on how the oil wealth of the Middle East shall be shared is worked out. Plans for major pipelines across Europe may set up new ways of thinking from which South Durham will benefit.

Henley's into AEI (Woolwich)

Of all the great industrial names that passed into limbo on New Year's Day, the effective date of AEI's divisionalisation, none had a more consistent record of success than that of W. T. HENLEY'S TELEGRAPH WORKS COMPANY LIMITED. Now part of Associated Electrical Industries (Woolwich) group, Henley's began on New Year's Day, 1837, in a workshop at Hayden Street, Minories, within a stone's throw of the Tower of London.

On the site of the present, now being run down, North Woolwich factory, William Henley opened a factory in 1859.

His standing in the cable industry was high enough for Henley to be consulted when the 1858 Atlantic telegraph cable failed and he was responsible for the successful Persian Gulf cable of 1,615 miles, which was laid in 1863. This was the first such length of submarine cable and it worked and went on working. The heavily armoured shore end of the successful Atlantic telegraph cables of 1865 and 1866 were made by William Henley, who died in 1882.

The company continued and in 1911 introduced the famous Henley Wiring system at Olympia. The Gravesend factory had been built in 1906 and new research laboratories were put up there in 1922. The Gravesend factory will become the main AEI works for the production of paper insulated cables.

Perhaps the most famous of all the company's products was the submarine petrol pipe line PLUTO which was essential to the Allied invasion of the Continent. PLUTO was manufactured together with SIEMENS.

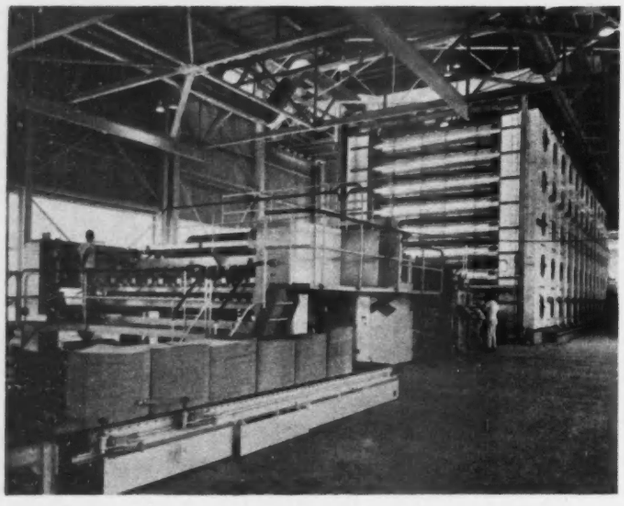
In the last decade of Henley's life under its founder's name, the first 110 kV 3-core oil-filled cable to be installed in Britain was produced for the electricity department of Belfast.

British Paper Pulp Mill in California

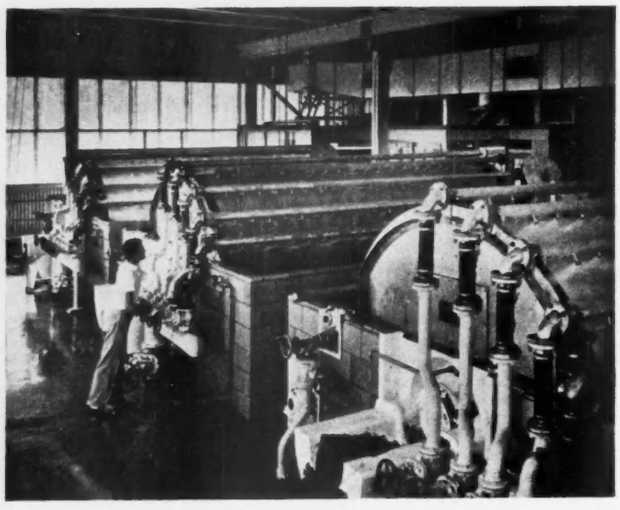
A Bowaters paper pulp mill which recently began production in USA has a pulp dryer which has a greater capacity than any similar unit in the world.

Catawba, South Carolina, is the site of a new 400 tons sulphate pulp mill opened by the Bowaters Carolina Corporation. It is the second Bowaters mill to be put into operation in the Southern United States of America. The mill produced its first pulp on 17 July, 1959, just over two years after site grading began.

A short time after the start up of Bowaters Southern Paper Corporation's mill in Calhoun, Tennessee, five years ago, it became evident that an additional source of kraft pulp must be found. In England, the company's paper mills required additional pulp which could not be supplied on a permanent basis by the expanding newsprint mill in Tennessee. Thus is was decided to take the necessary steps to erect another pulp mill in the United States. In 1955, an extensive search for the ideal site for the new pulp mill began. The Catawba site was chosen because it offered an adequate supply of water, wood and power, good transport facilities, a suitable climate, and a sufficient amount of readily available land.



The pulp dryer converts wet fibre into sheets. Fibres are locked together on revolving vacuum drums as water is removed. More moisture is removed by pressure.



Three washers remove the chemicals from the pulp. Pulp flows over revolving vacuum cylinders. When it comes from the digesters it is dark tan in colour. After washing it is very much paler.

The initial capacity of the mill is approximately 400 tons per day, although provision has been made for expansion in the future. The product is semi-bleached kraft pulp. In order to get all this pulp the mill consumes 800 " cords " (bales) of pine per day. Most of this wood will be obtained from the Piedmont sections of North and South Carolina, and it is delivered to the plant by road and rail.

Wood received by truck is unloaded by a 50 ton crawler-mounted crane into either of two 80 by 1,000 ft storage piles, or alternatively direct into a flume which carries it to the barking and chipping facilities. The wood delivered by rail can be either unloaded into the same storage piles or into the flume with the help of a self propelled rake. The flume is 3 ft wide and 1,000 ft long with railway tracks on both sides. Two pumps each with a capacity of 10,000 gallons per minute circulate the water through the flume at the rate of 5 ft per second.

After the wood has been debarked and chipped, it is fed into the digester building by a belt conveyor. The digester is the fundamental part of the pulp making process. It releases the wood fibres by chemical processing to make chemical pulp; as opposed to groundwood pulp which is obtained by mechanical grinding of the wood.

Chemical pulp is dearer to make than groundwood pulp, but it is much stronger and can be bleached to a pure white colour. It is made by boiling (or cooking) the wood in a chemical liquor in a sealed vessel under steam pressure. The boiling process dissolves the substances which bind the cellulose fibres together, thus enabling them to separate into a fibrous pulp. The characteristics of the pulp, and thus to some extent the quality of the eventual paper, are determined by the way the cooking is carried out; important factors include the length of time spent in cooking, which might be between six and 24 hours, and other conditions such as temperature and the composition of the chemical liquor.

Pure cellulose accounts for little more than half the weight of the wood. The paper maker seldom needs absolutely pure cellulose, and so he does not remove all the other natural substances. From the spent liquors of chemical processing, yeast, turpentine, road binders, commercial alcohol and other by-products may be produced. Nowadays, an increasing variety of woods and an increasing proportion of each tree is being made into paper.

The two most important types of chemical pulp are those known respectively as sulphite (more accurately bisulphite) and sulphate pulp. The two names indicate the chemicals used in two processes. Spruce lends itself more readily to the sulphite treatment, while pine which contains more resin calls for the sulphate process. The sulphate pulps of which the Carolina mill is a producer, are noted for their strength and are used a lot for making the stronger brown wrapping papers. For that reason, sulphate pulp is often known as kraft pulp since brown wrapping paper was given the name " kraft " (meaning strong) in Germany, where this paper was first developed. A third chemical process produces soda pulp.

In the Carolina mill there are five digesters making sulphate pulp, which have an inside diameter 12 ft and a height of 50 ft. Each digester has a capacity of 4,360 cu. ft. They are fabricated from 2 in thick steel and weigh approximately 75 tons when empty. They discharge through electrically operated blow valves into individual blow lines to a 28 ft diameter by 71 ft high blow tank. The blow tank can hold the contents produced by two and a half digesters.

The chemicals for the digesters are provided by measuring tanks located just above the operating flow. Flow from the measuring tanks to the digesters is by gravity. The blow steam passes through a cyclone in the head of the blow tank to an accumulator and the blow steam recovery system for the heating of water. The relief steam from the digesters is carried to individual separators thence to a relief cyclone, condenser, and decanter for the recovery of crude turpentine. Two 10 ft diameter by 34 ft tanks surrounded by an earth dyke have been provided for the collection of turpentine and for further separation of, and decanting of, this by-product.

The stock from the blow tank is pumped through a trap and an electromagnet to the refiners. It is controlled at 3½ per cent consistency by the motor load on the blow tank agitator and by a consistency regulator just ahead of the refiners.

For washing the pulp, three 11 ft 6 in by 20 ft vacuum type washers have peen provided. The stock from the final washer is delivered by a belt conveyor to a high density tank. The tank has a capacity of 150 tons of pulp and is equipped with dilution nozzles and an agitator at the bottom of the dilution of stock. The stock is controlled at 3½ per cent consistency by a pipeline regulator discharging into an agitated surge and blending chest.

The filtrate from the washers discharges direct to a 60 by 60 by 20 ft high steel filtrate tank divided into three equal compartments; one for each of the three washers. Adjacent to the filtrate tanks, a foam tank has been located. It is equipped with a foam breaker with provision for drawing off soap. The washers are located on the same floor level as the digester charging floor and are provided with hoods and exhaust fans. A 30 ton hand-operated bridge crane serves the washer operating floor.

The washed stock is pumped from the surge chest on the ground level through a consistency regulator to a mix tank which feeds two primary centrifugal screens. The accepted stock from these screens discharges by gravity into two 9½ ft by 12 ft valveless thickeners, and thence into a screened stock chest. The rejects from the primary screens discharge into a primary rejects chest, from which they are pumped through a consistency regulator and mix tank to the secondary screens. The secondary screen accep-

ted stock is discharged into a chest from which it is pumped through a series of centricleaners. The accepted stock from the centricleaners flows to the thickeners, and rejects are discharged to the process sewer.

The rejects from the secondary screens are discharged into a rejects chest from which they are pumped through a drainer headbox and magnetic separator to a tertiary screen. The accepted stock from the tertiary screen flows under gravity to the secondary screen accepted stock chest and the rejects flow through a drainer to a disc refiner. The refined rejects from the disc refiner are discharged into the secondary screen rejects chests to be recirculated to the tertiary screen.

From the screened stock chest in the screening area, the pulp is pumped at a regulated consistency through brushing jordans and a magnetic flowmeter to the chlorination stage of a three stage bleach plant.

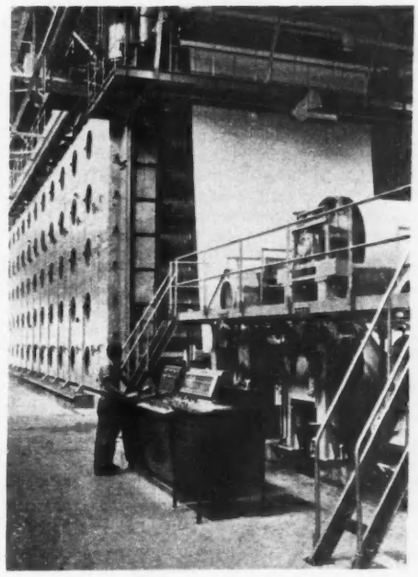
The chlorination stage consists of a 17 ft diameter by 90 ft high tile-lined chlorination tower which is equipped with a circulator at the bottom and a rubber covered skimmer and launder at the top. Chlorinated stock flows by gravity to a 9½ ft by 16 ft rubber covered vacuum washer with a screw conveyor for discharging the pulp through a steam mixer to the caustic extraction tower. This is a steel lined vessel 16½ ft in diameter by 60 ft high. Two circulators have been provided at the bottom of the tower.

Stock at the bottom of the tower is diluted by nozzles to a consistency of approximately 2½ per cent. After leaving the caustic tower, stock is diluted to 1 per cent consistency and pumped to a 9½ ft by 16 ft vacuum washer. It is then discharged by a cut flight conveyor through a high consistency double shaft mixer to a steel, tile-lined calcium hypochlorite tower. This tower is 18 ft in diameter and 60 ft high with two circulators at the bottom.

The high density stock at the bottom of the calcium hypochlorite tower is diluted by nozzles and pumped to a 9½ ft by 16 ft vacuum washer which discharges into a high density stock tower which is 18 ft in diameter and 61 ft high. Provision has been made for using the tower for secondary hypochlorite bleaching of caustic extraction should it become necessary in the future.

The washer vats have been constructed of structural tile. Washer seal pits are constructed of steel and lined with either stainless steel plate or rubber depending upon the service. Seal pits have been located on a mezzanine floor below the washer to minimise the generation of foam. Effluent from the chlorination and hypo stages is carried to a tile foam tower which also receives exhaust fumes and foam from all all three stages of bleaching.

The operating control room has been located on the operating floor of the bleach plant. The walls nearest the equipment are of glass to permit the operator to observe the equipment at all times. The building has been equipped with a freight elevator which serves all major floors and provides access to the digester, washing and screening areas. A 25 ton bridge crane has also been provided to serve the bleach plant.



Another view of the pulp dryer which is the first of its kind in North America. Its capacity is greater than any similar unit in the world.

An enclosed hot air circulating type dryer dries the pulp. It is fed by a feltless wet machine rated at 400 tons a day capacity. The wet end machine is designed to handle bleached, semi-bleached, and unbleached pulp. When operating on bleached pulp, stock is pumped from a 75 ton high density tank through a consistency regulator to a surge chest. From this chest the pulp is pumped through a consistency regulator and magnetic flowmeter into a fan pump which pushes dilute stock through a set of centrifugal cleaners to the sheet former headbox from whence stock enters the sheet former. The sheet former is a vacuum cylinder 11½ ft in diameter by 192 in wide. Four press rolls have been provided on the cylinder with pressures varying from 25 to 200 lb per linear in. The sheet is removed from the face of the forming cylinder by means of a rubber couch roll. A shredder conveyor is mounted at the discharge of the forming cylinder to repulp the sheet when threading the wet end of the pulp dryer. The press section of the wet end consists of two heavy-duty presses with a set of two 5 ft diameter predryers located between the presses. The first press is designed to operate at 1,800 lb per linear in pressure and the second at 2,800 lb per linear in pressure. Both presses are equipped with anti-friction bearings. From the second press the pulp sheet enters the dryer where it makes 17 horizontal passes for a total sheet length of approximately one-third of a mile inside the dryer.

The pulp dryer, which makes use of a very high velocity stream of air to convey the pulp sheet through the machine, is reported to be the first of its type to be used in North America.

This type of machine has proved to be superior to machines in which the sheet is conveyed by mechanical means since the air is used to convey the sheet and dry it at the same time. The high veolcity of the air also acts to obtain a higher specific evaporation capacity with the subsequent reduction in dryer size and higher operating speeds. To circulate the hot air, 120 fans driven by 12 h.p. motors have been provided in the dryer housing. The fans are arranged so that one fan at a time may be removed for maintenance with no loss of production. Drive rolls are located at the end of each pass within the dryer. The drive and bearing supports for these drive rolls are mounted outside the hot air zone for ease in maintenance and lubrication.

Heat for the dryer is provided by steam coils which are supplied with 150 lb per sq. in gauge saturated steam. An economiser is mounted on the roof of the dryer building to recover the major portion of the exhaust heat from the dryer. This heat is used to preheat the fresh air make-up to the dryer and the heating of water for the sheet former. To regulate the amount of tension in the sheet, a hold-back press has been located between the drying machine and the cutter. The pulp dryer machine is driven by a 200 kW motor generator set with d.c. drives mounted on each piece of equipment. Control devices have been provided to measure and control the tension between each section of the dryer.

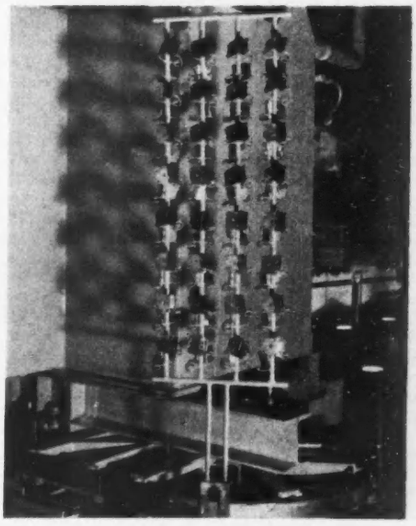
The pulp leaving the drying machine is fed into a cutter and layboy where it is cut into 26 in by 32 in sheets and accumulated in stacks weighing approximately 450 lb. The cutter is equipped with a dual set of slitters to cut either wrappers or sheets for baling. Stacks of sheets are conveyed from the cutter and layboy to a set of scales for adjusting the weight of each bale. From the scales the stacks are conveyed to an 800 ton capacity baling press. The bales are then wrapped and wire applied by means of semi-automatic wiring tools. Wired bales are then conveyed to a stacker which accumulates the bales in piles of five and automatically lowers them to ground level for shipment. Finished bales are conveyed from the ground floor level to railroad cars by means of fork lift trucks.

Automatic Plating Plant

The successful commissioning of a new automatic plating machine is reported by Thomas Crompton and Sons Limited at their Haydock, Lancashire, factory. The company are manufacturers of ironmongery for the aircraft, building, marine, automobile, railway and other industries.

The automatic plant which, in an eight hour shift, plates up to 30,000 parts with nickel or chromium, replaces a hand-operated system. At present, the machine is manually loaded, but provision has been made for automatic loading to be incorporated in the future. Parts are loaded on spring racks measuring about 30 in by 12 in as shown in the illustration. The machine is constructed in three main sections, carried on rolled steel supports, which provide an air space below. Heating is effected by coils and a heat exchanger using steam at 40 lb per sq. in.

The main processes in the operation are cleaning, pretreatment, and plating. A 0·0005 in bright nickel finish is deposited in 11½ min at 60A per sq. ft, or a similar coating of chromium can be obtained in 5½ min at 120A per sq. ft. Transfer of the plating racks is carried out by hydraulic cylinders fed by a separate floor-mounted oil pump and pressure assembly which is motor driven. A hydraulic drive control panel is embodied. Rectifiers and transformers are banked alongside the machine together with final drying station. The length of the installation is some 37 ft and the width is 13 ft.



A rack carrying plated components leaving the plating machine.

Air Cooling is More than Water Saving

Static air-cooled heat exchangers were first used widely where water supplies were inadequate or non-existent. They are now economic over a much wider field.

If there is no cooling water available, or if it is unsuitable, or too costly, air-cooled heat exchangers are the obvious answer. Studies of the relative installation and maintenance costs and of the operating characteristics of the two types of heat exchanger, however, have shown that the waterless site is far from being the only one where air is the right coolant to employ. Water supplies, or lack of them, remain, of course, the dominant factor in some cases. Even where water is adequate in quantity, it may be too dirty or chemically contaminated, so involving additional cost. There have been cases, too, where so much river water has been used by industrial plants that the temperature of the river has been raised above a level acceptable to the appropriate authorities. Even in tidal estuaries, in a long hot summer, the water has been known to become too hot in the vicinity of an industrial plant to do its job properly. As industrial developments proceed, so the water problem will become more acute, and the use of air as a coolant will develop.

Apart, however, from installations where site conditions leave no reasonable alternative to the use of air, there are many circumstances where its application is justified on the basis of installation or maintenance costs, or because it has operational advantages; it may be beneficial in all three respects.

After a detailed study of the subject, the Heat Exchange Division of Wellington Tube Works Limited, Great Bridge, Tipton, Staffordshire, has developed a range of air-cooled equipment which, in two basic types, will deal with a heat exchange problem of any size. For small local applications, as in some chemical works where the heat exchanger is an integral part of the process plant, the equipment resembles in appearance an industrial unit heater. It is usually arranged for horizontal air flow, and can be mounted in any convenient position. For indoor installation a duct can be provided to discharge the exhaust air to atmosphere. When the cooling requirements are large, the heat exchanger is mounted in the open air in a convenient position relative to the plant to be cooled, and the air flow is vertically upwards.

In the larger Wellington design it is the practice to use several smaller fans rather than a single large one. These fans are of the axial flow type, with an integrally-mounted motor, and the arrangement not only allows for simple installation, but has definite operational advantages as well. Because it is only necessary to provide wiring for the motors, and pipework for the liquid being cooled, the units can be mounted anywhere; the roof of the building housing the plant to be cooled is an ideal place. As the unit is, for mounting purposes, just a steel box, little structural work is required.

Wellington heat exchangers designed for use in north-west Europe are usually fitted with dual-speed fan motors. This enables the unit to be operated economically over the range of ambient temperatures encountered in this area. Some of the motors can be switched off and others run at reduced speed, as required, and a substantial power saving is the result. If the unit is intended for use in an overseas location where extreme temperatures—high or low—are normal, then single-speed fan motors are often adequate.

Switching in or out of individual fan motors gives stepped control of air flow, and this may be all that is required. On the other hand, if stepless control is needed, certain selected fans are equipped with louvres to regulate the air flow. These, used with the two-speed motors and with switching out, give a completely stepless variation of air flow from zero to full capacity. Because only a relatively small number of louvres is used, Wellington engineers have paid particular attention to their design, and they are heavily constructed and engineered to give long, trouble-free service. Operation of the motor switching, speeds and louvres can, of course, be controlled automatically from process instruments if required.

Air-cooled heat exchangers are often able to show substantial economies in place of the water-cooled type, and in view of an estimated total expenditure in the United Kingdom of several hundred million pounds annually on heat disposal, operating economies are well worth considering. It is not invariable, however, that the use of air as a coolant is best, and each case has to be considered on its merits. Where existing water-cooled installations are to be extended or replaced, for example, the extra cost of altering existing pipelines might be a decisive factor. The first cost of air-cooled equipment, too, is usually greater than that of its water-cooled counterpart, though this may well be offset by installation and operating economies.

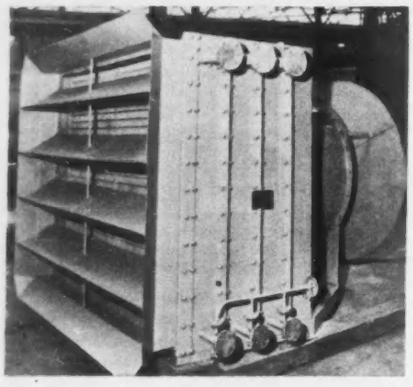
Some of the factors involved in making a choice are not quite as obvious as they might, at first sight, appear. If water is available from a cooling tower, it is often thought that air cooling is at a disadvantage, since the air is usually warmer than the water, and the temperature differences are consequently lower. In Great Britain this is a mistaken view. Cooling towers are usually designed to produce cooled water at a few degrees above a maximum (or optimum) summer, ambient wet-bulb temperature. As humidities in Britain are usually high, the resultant cooled water temperature is thus always at about the same level as the maximum (or optimum) summer, ambient dry-bulb temperature. Both air-cooled and water-cooled equipment start, therefore, from about the same temperature level when a cooling tower is used.

Water from the sea or from river estuaries will have an initial advantage over air, since their temperatures are often very close to the air wet-bulb value and may even be a little lower. Against this can be set the fact that such waters usually present corrosion problems. This can involve the use of expensive materials for tubes, which, though they are suitable for the water in question, may be attacked by the liquid to be cooled. Bi-metal tubes may then be necessary—again an expensive matter. On the other hand, with air-cooled equipment, corrosion by the coolant does not arise, and the tubes can be of any material to suit the liquid being cooled. Again, if water is the coolant, any leakage in the equipment might contaminate a product being cooled, or, conversely, the liquid itself might contaminate the cooling water. This latter condition is important in such installations as oil refineries, where it would be possible for oil to be discharged into the sea or river.

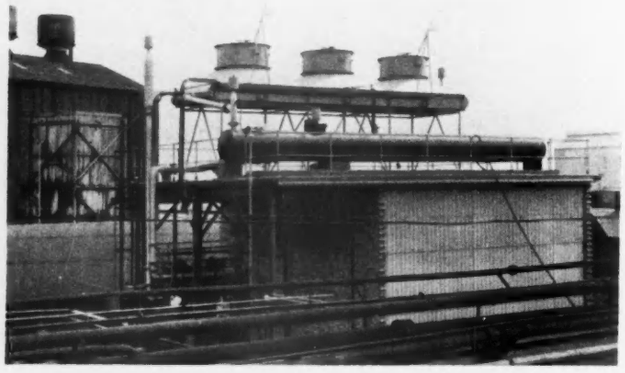
Then there is the space question to be considered. An air-cooled installation, even of large capacity, is likely to occupy much less space than a water-cooled plant of comparable output, if cooling towers and other ancillary equipment are taken into consideration. Furthermore, the air-cooled heat exchanger can be installed in any convenient position, occupying space which is otherwise unused; it can, for example, go on the factory roof.

Operational economies may not be confined to power consumption alone, though with several fan motors, some of which can be switched off while others are run at half speed, this can be an important factor when considered over a period. Air-cooling may be more suitable for the process in question, and so may give economies in this direction, too. Certain metallurgical furnaces, for example, can be cooled by a closed water circuit, the water itself being passed through an air-cooled heat exchanger. With this arrangement, the furnace walls can be kept at the required temperature without difficulty, and stresses and thermal shock induced by cooling water which is at times too cold are avoided, with consequent economies in furnace maintenance. Operating advantages may thus extend beyond the obvious field of low power costs and easy maintenance of the cooling plant itself.

It is obvious that in many instances a good case can be made for the use of air as a coolant, but there is one further aspect of the matter to which attention should be drawn. Air-cooling can only be successful if it is designed to suit the particular application; "off-the-shelf" equipment is not available, though designs are rationalised so that a suitable plant can be built up without undue delay.



(Left) Small air-cooled heat exchangers resemble in appearance a unit heater, and can be mounted integrally with the plant.



(Right) Larger installations, as this one for cooling a metallurgical furnace at the works of Murex Limited, are placed in any convenient position, often on the roof.

Pressure Gas Distribution

New to the gas industry in Great Britain is the high-pressure axial flow compressor installation in the Birmingham Division of the West Midlands Gas Board. A high-pressure distribution system, operating on the west and south-west sides of the city serves a large industrial and domestic load, and it will ultimately have a capacity of 2½ million cu. ft per hr.

Originally, the demand was met by high pressure storage on the outskirts of the city and a centrifugal compressor at Windsor Street gas works. Now, as a result of developments in design and manufacturing techniques, it has become possible to apply the axial flow compressor to the needs of the gas industry, and a machine of this type, made by W. H. Allen, Sons and Company Limited, Bedford, has been installed. This compressor has a capacity of 600,000 cu. ft per hr at 25 lb per sq. in gauge maximum, and will operate from 7½ lb per sq. in. up to the maximum. It is driven by a 1,150 h.p. electric motor through a scoop-controlled fluid drive and an Allen Stoeckicht epicyclic speed increasing gear (3,000 to 19,000 r.p.m.). These units which go to make up the complete compressor installation—motor, fluid drive, gear and compressor unit—are mounted in line, and have maximum operating efficiencies, respectively, of 95, 98, 98 and 88 per cent (adiabatic). A Serck gas cooler, supplied with cooling water from a circulating system, completes the equipment.

There are fourteen stages in the compressor with sixteen rows of blades in the stator; one row at the outlet acts as a flow straightener before the gas passes into the outlet diffuser. The other row of blades at the inlet acts as guide vanes.

A design requirement was that the plant should be capable of adjusting itself to meet the variation in gas demand during normal running, although it is intended as a base load machine for operation at full capacity and maximum efficiency.

Comprehensive control equipment supplied by Evershed and Vignoles Limited consists of proportional action control, which varies directly with the deviation from the desired value; integral action control, which changes at a rate varying directly with the deviation; and derivative action, which varies directly with the rate at which the deviation changes. Experience has shown that proportional control alone is adequate, and the plant now operates on this basis.

It is important that the compressor should not be operated in a surged condition, that is, when the flow and pressure are such that the flow process through the blading breaks down. Under such a condition flow reversal may occur, and severe blade vibration would follow. At some periods of operation, however, when the required flow is small and the pressure is high, or under starting and stopping procedures, surge conditions may obtain. In such circumstances, more gas than is required must be compressed, and the surplus is by-passed back to the compressor inlet. This is fundamentally inefficient, but increases the scope and flexibility of the plant. The by-pass valve is independent of the speed control equipment, as it must open and close automatically as the compressor approaches or moves away from surge. A surge controller is also incorporated, to lock the speed of the compressor before the operation of the automatic by-pass valve.

Economics of Automatic Boiler Control

Six Wilson super economic boilers, rated at 15,000 lb per hr at 150 lb per sq. in, are installed at the East Kilbride, Scotland, factory of Rolls-Royce Limited, the steam being used for process work and space heating. Arranged in groups of three, the boilers were equipped with Kelvin Hughes instruments at the time of installation in 1953. Automatic control was added to three of the boilers in 1958, detailed records of loading and fuel consumption of both groups of boilers were kept, and the results are now available.

A study of the figures showed that, with a comprehensively instrumented system, it was possible with skilled manual operation to obtain, for a short while, efficiencies bordering on those resulting from automatic control. The main advantage of automatic control is its ability to maintain the high efficiency over sustained periods—a practical impossibility when manual means are employed. Over a three-month period, during the winter months, the automatically controlled boilers maintained an average efficiency of 76·9 per cent, and for those under manual control the figure was 71·6 per cent—an increase of 5·3 per cent in favour of the automatic control. The actual test results are given in the appended table.

	Manual operation	Automatic operation
Average calorific value of fuel	12,000 Btu per lb	
Water evaporated (lb)	38,412,460	53,712,700
Fuel burnt (lb)	4,717,370	6,118,200
Water evaporated, lb of fuel (lb)	8·1	8·7
Average feed water temperature (°F)	162	162

An assessment of fuel consumption shows that 512,997 lb were saved by automatic control as compared with manual, and with fuel at £7 per ton, this gives a saving of £1,603 over the three months of the trial, more, in fact, than the cost of the installation.

Power Station Building in 1959

Continuing their programme of development, the Central Electricity Generating Board brought into commission during the year which has just ended, five new power stations and completed additions to ten more. Of the new generating plant brought into use, that at High Marnham, on the River Trent, is of particular interest. With a capacity of 200,000 kW, it is the largest unit so far installed by the Board, and has a greater output than any other unit in operation in western Europe. The associated boiler capacity is 1,400,000 lb per hr, and the turbine stop valve conditions are 2,300 lb per sq. in and 1,050° F. Reheating is provided to 1,000° F after partial expansion of the steam through the turbine.

New boilers have been installed at three stations, but not commissioned, as the associated turbo-generators are not yet available. These are: Northfleet, boiler No. 1 (Foster Wheeler), 860,000 lb per hr capacity; South Denes, boiler No. 4 (Mitchell Engineering), 550,000 lb per hr; and Spondon "H," boiler No. 24 (Foster Wheeler), 180,000 lb per hr.

CEGB Plant Commissioned During 1959

Name of power station	CEGB project group	Turbo-generator plant		Boiler plant		Main high pressure pipework
		Installed capacity in kilowatts	Maker	Capacity in lb per hr	Maker	Maker
Agecroft "C"†	Northern	1 × 120,000	Associated Electrical Industries	1 × 860,000	International Combustion	Stewarts and Lloyds
Belvedere L.P.*	Southern	3 × 60,000	English Electric	3 × 550,000	John Brown	Aiton
Blyth "A"	Northern	2 × 120,000	Associated Electrical Industries	2 × 860,000	Babcock and Wilcox	Babcock and Wilcox
Bold "B"	Northern	1 × 60,000	General Electric	1 × 550,000	John Thompson	John Thompson
Castle Donington	Midlands	1 × 100,000	Associated Electrical Industries	1 × 830,000	Babcock and Wilcox	Aiton
Drakelow "B"*	Midlands	2 × 120,000	C. A. Parsons	2 × 860,000	International Combustion/ Foster Wheeler	Stewarts and Lloyds
Elland	Northern	2 × 60,000	Associated Electrical Industries	2 × 550,000	Yarrow/John Brown	Stewarts and Lloyds/John Thompson
Ferrybridge "B"	Northern	1 × 100,000	C. A. Parsons	1 × 760,000	Babcock and Wilcox	Stewarts and Lloyds
High Marnham*	Midlands/Northern	1 × 200,000	English Electric	1 × 1,400,000	International Combustion	Aiton
Little Barford "B"*	Southern	2 × 60,000	C. A. Parsons	2 × 550,000	Foster Wheeler	Stewarts and Lloyds
Marchwood	Southern	1 × 60,000	English Electric	1 × 550,000	John Thompson	Stewarts and Lloyds
Portishead "B"	Southern	1 × 65,000	Associated Electrical Industries	3 × 300,000	Mitchell Engineering	Stewarts and Lloyds
South Denes	Southern	1 × 60,000	Richardsons Westgarth	1 × 550,000	Mitchell Engineering	John Thompson
Spondon "H"	Midlands	1 × 10,000	Associated Electrical Industries	1 × 180,000	Foster Wheeler	Aiton
Willington "A"	Midlands	1 × 100,000	English Electric	1 × 830,000	International Combustion	Aiton
15 Stations including 5 new stations and 2 new sections	3 Project groups	21 Turbo-generators having an aggregate installed capacity of 1,775,000 kW	—	23 Boilers having an aggregate installed capacity of 14,700,000 lb per hr	—	—

* New stations, first commissioned in 1959.
† New sections.

On the Shelf

By Frank H. Smith

We librarians frequently have occasion to ring up other librarians and there are some points that I, at any rate, find irritating when I have to do the ringing. One of the mostest occurs when the person the other end doesn't know the answer off the cuff and goes chasing off to the other end of his (or her) library—or so I assume. If *I* have to do that sort of thing I invariably offer to ring back (unless the inquirer is somewhere in Copenhagen or Muckireekie) for the simple reason that it saves me breaking my neck to give an answer that may not be complete and it saves the person inquiring from wasting his time and getting a hot left ear. If, when I ring back, I get one of those "hold on a minute while I get her" types and then hang on for five minutes, *that* irritates me too. It's just as easy to say "She's not here at the moment, can I get her to ring you?" These may seem small things but I do feel that it is time somebody got out a code of conduct for the telephone. It will save a lot of ulcers.

The British Iron and Steel Research Association (BISRA) of 11 Park Lane, London, W1, have done a bit of changing around. Miss I. M. Slade, the information officer, has gone over to Battersea (where BISRA has its operational research department) and the information department has now merged with the development and exploitation of the results of research under Mr. L. W. Stevens-Wilson. All this must mean something or there would not be a Press release about it. I only hope I have paraphrased correctly. The new department will be known as Development and Information Services. Whether such departmental take-overs are Good Things or not, might be a subject for debate. I wonder why Aslib never has a debate?

The Aslib meeting for 2 February looks good. An appreciation of the Speed-up-your-Reading programme of the Carborundum Company. I wonder if they grind your eyeballs so that they swivel more easily? Find out by turning up at 3 Belgrave Square, SW1 (behind St. George's, Hyde Park Corner) at 5.30 in time for a preliminary cuppa. But perhaps you'd better write and tell the director you are coming so that there will be enough cups.

A little late, perhaps, but blame Christmas. Dated Autumn 1959 is the first number of *EMI electronics post*—export journal of EMI Electronics Limited. Contents include a short description of Studio Five (Associated Rediffusion's 14,000 sq. ft effort), an electronically controlled giant drill, robotugs (driverless trolleys), and other snippets. Plenty of pictures and not too technical.

The tenth edition of *The World of Learning* should be ready by the time you read this. Europa Publications, 18 Bedford Square, London, WC1, at £7, for which you get 4,000 universities and colleges, 4,000 libraries and museums, 5,000 learned societies and research institutes and 80,000 persons active in these organisations. I like the word "active."

Collet's Holdings (44-45 Museum Street, London, WC1) are organising Russian lectures next autumn if there is sufficient response. They are taking names now, or—as the Americans would say—as of now. They are also doing a line of German scientific and technical books at reduced prices—list on application.

The American Institute of Physics, 335 East 45 Street, New York, 17) brings out a new bimonthly *Journal of Mathematical Physics* starting in February. The sub. is $11 in this country or anywhere else outside the US and Canada, where it is a dollar less.

I like to picture some of those drab types one sees walking about with a canvas or a drawing portfolio under their arms buying the McGraw-Hill *Encyclopaedia of World Art*. In 15 volumes, it costs £171 8*s* 6*d*.

Interlinked Machines

Automation Today and Tomorrow. By L. Landon Goodman. *Iota Services Limited, 38 Farringdon Street, London, EC4.* (40*s*)

"Ultimate automation based upon atomic power could make our modern industries look as primitive as the methods of the Stone Age men look to us now. If we look hopefully upon the shape of things to come, we can visualise automation as the greatest blessing mankind has ever known." These words of Einstein are quoted by Mr. Landon Goodman in his earlier book *Man and Automation*. There can be no more authoritative assessment of the vast importance of the subject on which Mr. Landon Goodman is undoubtedly a leading authority.

Automation Today and Tomorrow does not foretell the future role of Great Britain in world affairs but it does deal prophetically with vital factors in future development. For instance the need for research and for many more trained engineers. The author issues a solemn warning to industry when he says that without these things a company may not survive at all in the forthcoming automation age. The same is true of the country as a whole and the publishers would do well to add Government departments to the list of people and bodies to whom the book is addressed.

The author shows by many examples of processes, applications and industries how wide is the scope of automation. He is a master of concise and lucid description and in his comparatively short book (117 pages) covers a surprising number of examples. There are no diagrams, mechanical drawings nor illustrations but the clarity of description is such that visual aids are scarcely missed. His object is to present a progress report over as wide a field as is necessary for effective guidance. In a few cases his descriptions are in greater detail. He is to be commended for permitting his wide human interests and sound philosophy to peep through the text occasionally to enhance the enjoyment of the reader who, as he reaches page 117, may well be convinced that the author possesses prophetic powers.

Of his previous book one authoritative critic wrote: ". . . it is to be hoped that *Man and Automation* will reach the widest possible public. Anyone who has bought earlier books on the general aspect of automation would be well advised to buy this book and throw the rest away." This is high praise—with perhaps a touch of poetic exaggeration—but many will agree that it is justified.

But it does not seem to have turned the author's head for the second part of his volume comprises a bibliography (158 pages) larger than his own part one.

This is stated to be "Compiled by Iota Services Ltd." but it must have been carried out with the author's approval and, no doubt, with his occasional advice. It reveals that a considerable literature has accumulated largely during the past few years, although a few references go back 30 years or more.

It is to be hoped that the full title *Bibliography of the Automatic Factory* does not mislead potential purchasers as to its scope, for automation serves not only whole factories but, much more frequently, parts of factories and also many other human activities as Mr. Landon Goodman makes abundantly clear in his part one. This first part has no index but the table of contents is well arranged and detailed and the headings in the text are so clear as to make an index unnecessary in a work of this length.

By contrast in the second part there is an a excellent subject index as well as an author index of nearly 500 names. The subjects refer to many aspects and applications of automation in a number of original languages and frequently in translations. This second part covers presumably the whole of a modern literature the growth of which can have been realised only by a very few people. It is an excellent piece of work—one which no industrial organisation can afford to be without.

C. W. Presland

Latent but Lethal Contamination

Symposium on Radioactivity in Industrial Water and Industrial Waste Water, held in Boston, 26 June, 1958. ASTM Special Technical Publication No. 235. *American Society for Testing Materials, Philadelphia, USA* ($2 members and $2·50 non-members)

Waste Treatment and Environmental Aspects of Atomic Energy. Volume 18 of the Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy 1958. *United Nations, New York; HMSO, London.* (118*s*)

Natural radioactive compounds had already had an honourable and relatively long history of "peaceful use" before the catastrophic event of the 5 August, 1945, demonstrated the great power of atomic energy. Since then progress in nuclear technology has been almost frighteningly rapid. If it is the destructive aspect of this progress that has, perhaps, been most noticed this is not unnatural in view of its newsworthiness. But in its impact on many fields of science and engineering, radioactivity has its more important potential both for good and ill. Unless man encompasses his own suicide nuclear energy will not be used for destruction, but it is finding increasing peaceful application; its safe handling and disposal here is a matter of great concern to engineers and politicians, since the scope for serious error is quite great.

It is with these circumstances in mind that the British Government has recently introduced into Parliament the Radioactive Substances Bill, which is intended to bring the handling and disposal of these materials under central control.

The present degree of dissemination of knowledge on these matters makes central control inevitable, but, at the same time central control should not be used as an excuse for continued ignorance. Those of us therefore, who are concerned with the engineering control of the environment are always glad to see a new book on the control of radioactive wastes.

The first of the two books under review is a rather slight volume, which records the proceedings of a symposium held in Boston, Massachusetts, in June, 1958. No doubt the original papers were valuable to the symposium participants, but the great condensation demanded by American conference conditions has made the permanent record in this book much less useful than it could have been. There are six papers in all, together with a "summation"—soon it will be easier to understand French or German than American, if the present US tendency to destroy accepted English usage continues. Four of these papers are on various aspects of analysis of water, vegetation and other possible bearers of radionuclides. While these papers do not set out to provide complete manuals of analysis, they do offer useful reviews of methods and full bibliographies. There is no index.

Although there is a wide interest in radioactivity, the number of people who may fairly be called experts in the essential health and safety precautions are few, and I am sometimes appalled at the enormous burden of exposition that these few have to sustain. There have been two United Nations International Conferences

on the Peaceful Uses of Atomic Energy, in 1955 and 1958. At the second 2,100 papers were submitted; only a comparatively small number of these could be discussed at the conference. The complete proceedings in English runs to 33 volumes; the second book under review is volume 18 of this series.

The presentation is most attractive and readable. Since, for several years to come, this must be the basic source of information on radioactive waste treatment and on the environmental aspects of atomic energy, it is unfortunate that the volume itself has no index, the index for the whole proceedings constituting Volume 33 of the series.

Having been brought up to think of sewage treatment in terms of a reduction of " contamination " of 90 to 95 per cent, the first impact made on one is by the vastly greater degree of " decontamination " required before the waste can be discharged with any degree of insouciance. Radioactive wastes can be disposed of only by dispersion and by immobilisation. The low-activity wastes, and those which can be rendered of low activity by chemical means, may be discharged to water where sufficient dilution is available. But the permissible level of activity is almost immeasurably low. The high-activity wastes must be immobilised and stored. Liquid wastes may be stored in watertight underground tanks. Certain wastes can be canned and the steel containers dumped at sea, sometimes after being encased in concrete.

It can be appreciated that the storage of liquid wates, sometimes for long periods, is becoming increasingly difficult as the quantities involved increase. Some of the liquid high-activity wastes are associated with high concentrations of aluminium. A good deal of research has been directed towards the production of ceramic glazes which could incorporate these wastes and so render the fission products resistant to leaching. Clearly such stored ceramics would be much less liable to escape owing to damage of the storage facilities by bombing or earthquake.

In addition to liquid wastes the processing and use of radioisotopes can produce gaseous wastes, some of which, again, may be discharged to the atmosphere. As we saw at Windscale such discharge may occasionally occur at a higher level of activity than is intended. In this respect the World Meteorological Organisation provided an interesting and valuable review.

Clearly a reviewer cannot pick out all the plums from such a rich mixture, but it may be said that the ASTM book will be of value to those concerned with water or stream analysis, especially if they are not yet undertaking " radio-analysis," and the United Nations volume cannot fail to be a mine of information to all those concerned with the topics it covers.

PETER C. G. ISAAC

Sensitive Organism

Process Dynamics. By DONALD P. CAMPBELL. *John Wiley, New York; Chapman and Hall, London.* (84*s*)

" Because it makes you think " is what schoolmasters say to boys who ask why they have to learn Latin, which seems to them a severe discipline leading to no immediate benefit. This book is addressed to the chemical engineer or to the designer of process plant to make him think; he may even dislike parts of it but there will be a growing conviction as page after page is considered that it is doing him good. Only by such pains do the mind and the outlook grow. It is a sorrow to record that the author of the book is dead: the seven pages of preface from his hand are a vision of how much more he had in mind to do.

The process designer is often so busy with calculation that he fails to realise how much of the plant equipment is introduced purely on his judgment or on the tradition within the profession embodied in empirical formulae. The purpose of process dynamics as a subject, and of this book in particular, is to subject the whole process to a more detailed mathematical study; to see it as an organic whole and so choose the dimensions and quality of each component part, be it heat exchanger, surge drum or pump, that the behaviour of the whole can be forecast and its susceptibility to disturbance or change predicted. Only in this way can instrumentation and automatic control be properly applied. The design is not to be handled by a succession of independent experts, of whom the control engineer is usually the last. All aspects of the plant design and behaviour must be considered in parallel, because none is independent of the others. Whether this is another Utopia or really practicable with ordinary mortals is for the practising chemical engineer to judge. But he must hear the plea. The merit of this book is that it presents the plea with energy, competence and conviction.

The author graduated from the Massachusetts Institute of Technology with a doctorate in electrical engineering and certainly has every qualification for his task. The reader is expected to remember as much mathematics as will make him familiar with partial differential equations and the Laplace transformation, otherwise the book may mean little to him. And the reviewer may perhaps be allowed to caution him against reading hastily, because much is taught by implication and the author's preface must be kept in mind.

The chapters of the book consider the basic aspects of design, kinetics of materials, motion of fluids, tension within bodies, heat transfer, mass transfer and general process dynamics. They are made aspects of an operating unit, with material always flowing and undergoing physical or chemical change, and the discussion establishing a differential equation with respect to time. The application of control mechanisms is thus always brought to the forefront, and modifications often suggested to make the application successful.

The book is very well produced and clearly printed. Every engineer or designer of plant should look at it; and if he then feels that it is addressed to him, it should be purchased to be read often at leisure.

D. P. PLUMMER

Know-How for the Welder

Welding Handbook. Section II: Welding Processes Gas, Arc and Resistance. Edited by ARTHUR L. PHILLIPS. Fourth Edition. *American Welding Society;* and *Cleaver-Hume Press Limited, 31 Wright's Lane, Kensington, London, W8.* (72*s*)

Welding is a technology of great national and international importance and plays an ever increasing part in a country's productivity effort. Welding science has transformed the ancient blacksmith's art into a major fabricating process. In the United Kingdom, no less than 20 different industries support cooperative research directed to improvements in welding techniques and improved design for fabrication by welding. In the United States, the Welding Research Council is spending about $1 million a year on basic research alone. The Soviet Union is also known to be making a considerable effort in this field and, during the next seven years, plans to increase the mechanisation of welding in the boiler making and locomotive industry by about 50 per cent, in the building industry by about 60 per cent, in rolling stock manufacture by 70 per cent and in shipbuilding by 85 per cent. It is also worthy of note that at least 25 nations now support the International Institute of Welding which was only formed in 1948.

With this increased recognition of the importance of the subject, an authoritative handbook on welding is a most valuable addition to technical literature. The *Welding Handbook* published by the American Welding Society has proved to be, over the years, a valuable source of guidance and instruction to all engaged and interested in this important field of technology. Previous editions have appeared as a single volume at intervals of about eight years, the last being published in 1950. The fifth edition is now being produced in five separate volumes over a period of five years. This will not only simplify the task of revision for future editions but has provided the opportunity to adopt a new format with a modern method of numbering the sections and sub-sections so that the subject is presented in a more attractive and readable form, with the advantage of quick and easy reference.

The five parts of the new *Welding Handbook* covering various aspects of welding are as follows: (1) basic principles and data; (2) welding processes, gas arc and resistance; (3) miscellaneous processes and cutting; (4) metals and their weldability; and (5) applications. Of these, Part 2, which is wholly devoted to welding processes should have the widest general appeal and be the most useful to the welding engineer.

Many factors have contributed to the rapid development of welding during the last decade; not least of these have been the demands of the engineering industry for welded plant and equipment in a wide range of ferrous and non-ferrous metals, capable of withstanding the ever increasing service stresses and temperatures. In particular, one is reminded of the impact of the atomic and jet age with their special demands for higher standards of performance from metal fabrications. Welding is the most economical and satisfactory method of joining metal parts to ensure pressure-tightness, strength and corrosion resistance under the most severe service conditions. To achieve these results, an intensive research effort was necessary to solve the welding problems involved.

The result is that we now know more about the fundamentals of welding processes such as the influence of electric arc characteristics, flux and inert gas shielding, on the quality of fused metal joints, as well as the effect of welding temperatures and cooling rates on residual stresses and metallurgical structure. Equally important has been the correlation of welding techniques with the static and dynamic strength properties of joints and weldments. The new information resulting from this scientific approach has resulted in better control of welding operations. Furthermore, it has led to development of new processes that ensure complete penetration and high deposition rates of molten metal so that they are readily adapted to provide an increased level of mechanisation in production welding. A glance at the table of contents of the book reveals no significant changes in the subject matter as compared with the corresponding chapters in the previous edition. Nevertheless,

Continued on next page

more careful study reveals refinements to the older processes and details of more recent developments.

One of the advantages of a separate volume for processes is that it enables the right emphasis to be given to each one in relation to their application. For example, treatment of the shielded metal-arc process has been extended and is now the subject of a separate chapter; atomic hydrogen welding is now grouped with metal-arc welding and impregnated tape metal-arc welding. Stud welding too, is treated as a special application of arc welding and is dealt with in the chapter on arc welding equipment.

As might be expected, the subject of welding equipment has necessitated a certain amount of revision and the opportunity has been taken to present and discuss the subject in a more logical order. Besides the separate chapters on gas welding, brazing, arc welding and resistance welding equipments, the practical aspects of selection, control and maintenance are included under individual processes. A number of other common features are also discussed under the individual processes such as fundamentals of the process, materials, effect of process on the metals welded, weld quality, applications, safety and other precautions.

The chapter on standard welding symbols and non-destructive testing symbols will prove most useful to designers and publishers of technical literature concerned with welding. The difficulty in conveying information from the designer to the welder in the fabrication shops or on erection sites is well known, and the wider use of such a scheme is to be encouraged. It is interesting to note that the scheme outlined has much in common with that recommended in BS 499: 1952. The book is essentially an account of current industrial welding processes in the United States. This does not limit its usefulness since the American contribution to developments in this technology has been outstanding. In preparing this book, the American Welding Society and its handbook committee, under the able direction of Dr. Robert D. Stout of Lehigh University supported by the eminent members of the reviewing committees have rendered a great service to the welding industry. The information, whether it be in the form of tabulated data, schematic drawings, reprints of photographs or text is presented in a delightfully clear, simple and impressive form. The book should be read by all concerned with welding, whether a student or professional engineer. It is of special value to the practising or prospective welding and production engineer.

E. I. BRIMELOW

New Books

Conductance Design of Active Circuits. By KEATS A. PULLEN, JR. *John F. Rider, New York; Chapman and Hall, London.* (80*s*)

Quote: "Here is a NEW approach to the design of active circuits. . . . The conductance approach utilizes a technique whereby a non-linear circuit may linearised on a point-by-point basis."

Applied Hydrodynamics. By H. R. VALLENTINE. *Butterworths Scientific Publications.* (50*s*)

The author is senior lecturer in civil engineering at New South Wales. A bias to practical applications makes it different from the average mathematical treatise.

Directory of Periodicals Published by International Organisations. 2nd Edition. *Union of International Associations, Palais d'Egmont, Brussels 1.* (21*s*)

Gives name of organisation, title, address of publisher, date of first issue, language(s), frequency, format, and one or two other details.

The British Engineers' Handbook, 1959. *The British Engineers' Association.* (21*s*)

An annual classified handbook of members of the BEA and their products, giving an indication of where to buy a ship, a treacle tap, a homogeneous tin lining and other mechanical equipment *except* aircraft or automobile. A classified index is repeated in French, German, Portuguese and Spanish and there is an index of trade names and marks.

Précis de Mécanique des Sols. 3rd edition. By ARMAND MAYER. *Librairie Armand Colin, 103 Boulevard Saint-Michel, Paris 5.* (360 *fr.*)

A paper-back summary of soil mechanics, conveniently laid out and illustrated, and with short bibliographies drawn from French, German and English writings respectively.

Heating and Ventilating. By OSCAR FABER. New edition. *E. and F. N. Spon Limited.* (30*s*)

Although ten years have elapsed since the first edition, this book retains its original purpose: to serve as an introduction to the subject. Faber's text has been revised by L. N. Doe.

Trocknungstechnik. By O. KRISCHER and K. KRÖLL. Volume 2: Trockner und Trocknungsverfahren, by K. KRÖLL. *Springer-Verlag.* (*DM* 46·50)

With their usual thoroughness, the Germans take drying technique seriously. Well indexed and with many references this volume alone runs to 588 pages.

An Introduction to Product Design and Tooling. By S. C. DAVID; **Notes on Pipework Design.** By A. A. SMITH; and **The Geometry of Conical Pipes, Bends and Joints.** By W. SELLAR. *All published by the Association of Engineering and Shipbuilding Draughtsmen, Onslow Hall, Little Green, Richmond, Surrey.* (3*s* 6*d* each)

These three pamphlets are additions to the range of reference works published by the AESD, and follow the same general plan. Conciseness is characteristic of all—it is enforced by space limitation—but each of the subjects is surveyed thoroughly. The pamphlets are aimed at a wide readership from the young draughtsman who is just embarking on his career to the older man who finds himself confronted with a new type of design problem for which he has neither the experience nor the data at hand.

Labor-Management Relations. By CHARLES WIEDEMANN. *Reinhold, New York; Chapman and Hall, London.* (30*s*)

An American view of the subject by a management consultant, and concerned with the legal aspects rather than welfare. The principles outlined are said to apply equally to "blue collar, white collar and professional employees."

Tables of Physical and Chemical Constants. 12th Edition. *Longmans Green.* (25*s*)

This volume needs no introduction. It is significant that new editions are now coming at shorter intervals (1948, 1956, 1959) and it is now "prepared under the direction of an editorial committee," having originally been compiled by Drs. G. W. C. Kaye and T. H. Laby.

Conduction of Heat in Solids. By H. S. CARSLAW and J. C. JAEGER. 2nd Edition. *Oxford University Press.* (84*s*)

H. S. Carslaw started writing on the subject in 1906, and the first edition of this book dates from 1946. In 1954 he died and J. C. Jaeger prepared the new edition. Some parts of the discussion (heat generation, surface heating, etc.) have been extended and three new chapters added.

Van Nostrand's Dictionary of Guided Missiles and Space Flight. Edited by GRAYSON MERRILL. *Van Nostrand.* (131*s* 6*d*)

One of the most up-to-date entries is probably that referring to the failure of Explorer V on 24 August, 1958. The word "dictionary" is something of a misnomer, and the form of coverage will be familiar to all users of the Van Nostrand Scientific Encyclopaedia. The contributors are drawn from the ranks of the missile manufacturers and the Services.

Pratique de la Mesure et du Contrôle dans L'Industrie. By J. BURTON. Volume 2. *Dunod, 92 Rue Bonaparte, Paris 6.* (4,600 *fr.*)

Volume 1 dealt with pressure, level and flow, while the present volume covers temperature, humidity and density, and the third, now in preparation, is to cover the measurement of calorific values, pH content and conductivity, gas analysis, and other types of measurement.

Ground Water Hydrology. By DAVID K. TODD. *Wiley, New York; Chapman and Hall, London.* (86*s*)

The future role of ground water resources in the United States. Professor Todd's volume deals with the location and exploitation of sources of supply, with the determination of the extent of resources, and the dangers of pollution by natural and industrial contaminants, including nuclear wastes.

Principles of Frequency Modulation. By B. S. CAMIES. *Iliffe.* (21*s*)

The relative advantages of frequency modulated and amplitude modulated receivers under various interference conditions are considered. A final chapter covers non-broadcasting applications of f.m., including radar, telegraphy and facsimile transmission.

The Reviewers

Mr. C. W. Presland's early training was in the design and manufacture of mining machinery, tin and gold alluvial dredgers, heavy transporters, conveyors, and other mechanical handling plants. After holding senior appointments in Government and private factories, he entered private consulting practice. Mr. Presland is an M.B.E. and an M.I.Mech.E.

Mr. Peter C. G. Isaac is senior lecturer in public health engineering in the department of civil engineering at the University of Durham. He is the honorary secretary of the British Occupational Hygiene Society and a member of the Minister of Labour's industrial Health Advisory Committee. Mr. Isaac holds a B.Sc. (Eng.) and an S.M. (Harvard) in sanitary engineering, and is an M.I.C.E., an M.I.W.E., an M.Inst.S.P., and an F.R.S.H.

Mr. D. P. Plummer serves in the technological department of the Shell Refining Company and has completed 24 years in design and operation of plant, chiefly for the refining of petroleum. He is an M.A., a B.Sc. and an M.I.Chem.E.

Mr. E. I. Brimelow is a metallurgical engineer with the British Welding Research Association. From 1936 to 1944 he was engaged at the Royal Aircraft Establishment, Farnborough, in research on high-temperature materials. In 1949 he became a scientific adviser to the Ministry of Works and was later transferred to DSIR. He is an honours graduate of Liverpool University and a former member of the editorial staff of ENGINEERING.

Trade Publications

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Teleprinter Equipment. CREED AND CO. LTD., CROYDON. Reperforator for recording messages on paper tape. Teleprinter providing data and messages in printed page form. Details of teleprinter installation at Wiggins Teape and Co. Ltd. Three leaflets.

Small Tools. THOMAS CHATWIN AND CO., Victoria Works, Great Tindal Street, Birmingham 16. A range of long-life small tools are fully specified. Illustrated 10 page brochure.

Chains and Chain Drives. RENOLD CHAINS LTD., Renold House, Wythenshawe, Manchester. Chains and drives for flow line production of many products with drive and control mechanisms. Ten page illustrated leaflet in colour.

Fuel Handling. W. J. JENKINS AND CO., LTD., P.O. Box No. 3, Retford, Nottinghamshire. Installations for which the company has recently been responsible, including a blanket conveyor at a gas works, resonance screens, dewatering screens, wagon tippers, belt conveyors, feeders, crushers and scraper conveyors. Illustrated leaflet.

Grinding Mills. DOMINION ENGINEERING CO., LTD., Montreal, Canada. Examples of ball and rod mills made by the company. Illustrated brochure.

Multileaf Spring Design

Multileaf springs are in most cases primitive in design and wasteful of material. Toledo Woodhead Springs Limited, feeling that there was scope for development, have examined the problem from first principles.

Using rational mathematical methods, more realistic leaf spring designs have been evolved by Toledo Woodhead Springs Limited, Aycliffe, Nr. Darlington. This has led to leaf springs in which the ideal of uniform stress is approached far more closely than in the past, with less material and at lower cost. Calculations revealed the poor stress distribution in springs of contemporary design, a distribution confirmed by strain gauge tests. Equivalent leaf springs, designed in accordance with this more rational theory, have been tested in service and by strain gauge. Fig. 7, in fact, shows the test set up for a 2-leaf design, so chosen because it is rather a critical case. When compared with conventional leaf springs, the new design shows weight savings of about 30 per cent, with fewer leaves and a better spring shape.

Admittedly, mathematical methods of analysis were worked out years ago, but they were rather tedious and so their application was limited. However, the approximate text-book treatment was quite suitable for finding the spring rate (the main design requirement); it also gave some idea of the spring stresses, which were then looked after by using large factors of safety. While satisfactory in the past, this method does not match up with present-day requirements for, say, motor vehicle springs.

The text book theory of the multileaf spring is commonly illustrated by the sort of spring shown in Fig. 1. Theoretically, this is perfect but in practice it cannot be realised, because it assumes an infinite concentration of load at the leaf tips. The conventional methods of spring design start from this text-book treatment, and a number of more or less empirical corrections are then applied in order to arrive at a practical result. This leads to a serious departure from the ideal of constant stress throughout the material of the spring, since the stress distribution between the leaves is extremely sensitive to any systematic departure from the correct proportions.

To illustrate this, Fig. 2 shows the maximum bending stresses in a conventional 4-leaf spring having leaves of equal thickness, equal steps between leaves and no leaf tapering. It is clear that the longer leaves are too stiff, the stress in the bottom leaf being as much as 42 per cent higher than the stress in the main leaf. In an attempt to overcome this difficulty, the leaf tips are tapered (in a more or less haphazard manner), the lower leaves made thinner than the upper, and "nip" or "pull" introduced into the spring. In the absence of rational analysis, none of these expedients is likely to result in a uniformly stressed spring.

To show the effect of the new treatment, a comparison is made between a conventional 6-leaf spring (Fig. 3), at present in production, and a Toledo Woodhead 4-leaf spring equivalent (Fig. 4) designed by the more rational treatment. Relevant data is:—

	Original spring	Toledo Woodhead spring
Weight	23·3 lb	16·25 lb
Number of leaves ..	6	4
Maximum measured stress (lb per sq. in)	83,000	74,000

The stress distributions at the working load, based on actual strain gauge measurements at the points shown, are given in Figs. 5 and 6. It will be clear that the stress variation from leaf to leaf in the original design of Fig. 5 is considerable, while in the Toledo Woodhead design of Fig. 6, the ideal of constant maximum stress throughout all the leaves is very closely approached, as shown by the mean stress line. It is interesting to note that these results did not depend on extreme accuracy of manufacture; the dimensional accuracy of the Toledo spring was, in fact, rather less than that of the corresponding conventional spring.

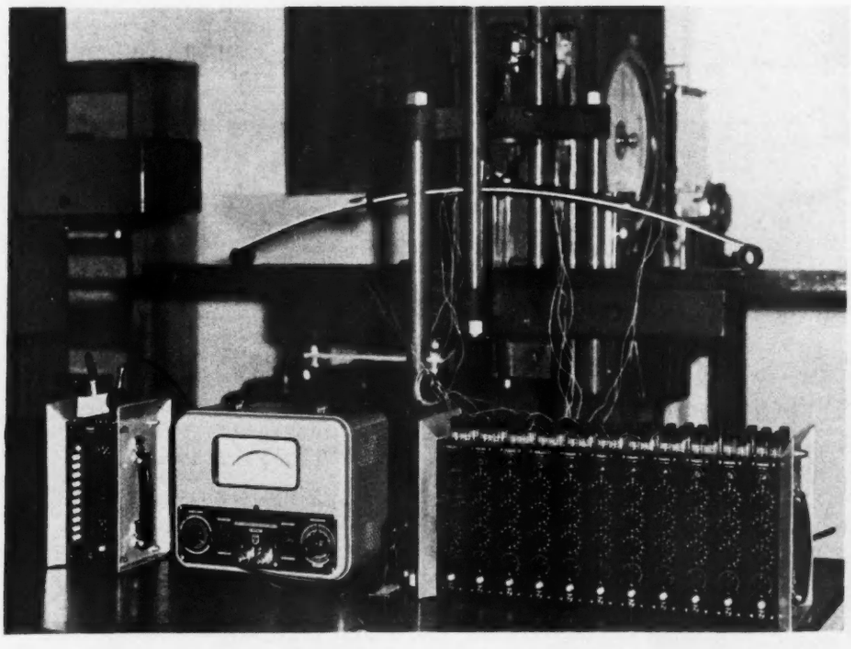


Fig. 7 Test set up for the 2-leaf spring designed in accordance with the more rational method.

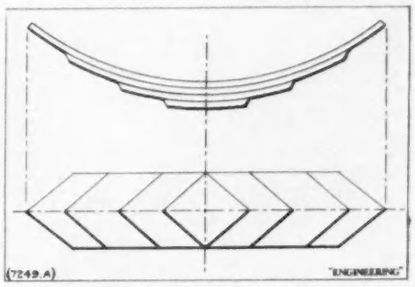


Fig. 1 Textbook design of multileaf spring.

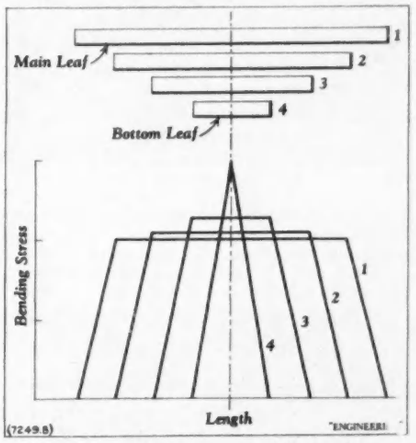


Fig. 2 Bending stresses in 4-leaf spring.

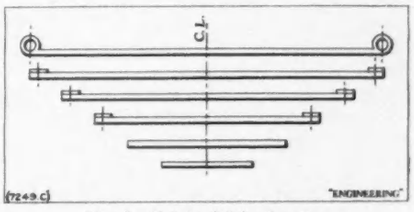


Fig. 3 Original 6-leaf spring.

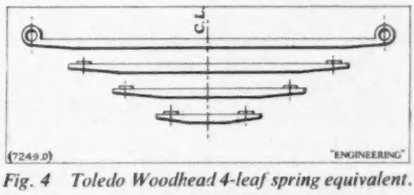


Fig. 4 Toledo Woodhead 4-leaf spring equivalent.

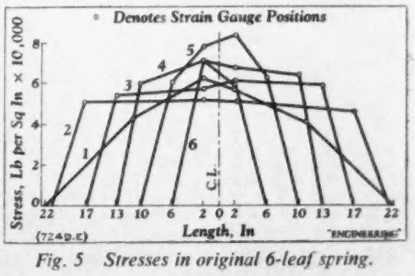


Fig. 5 Stresses in original 6-leaf spring.

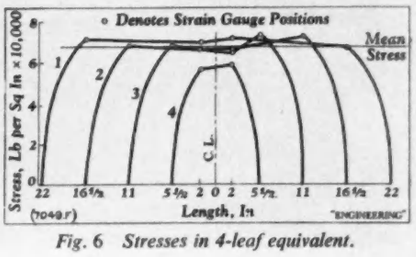
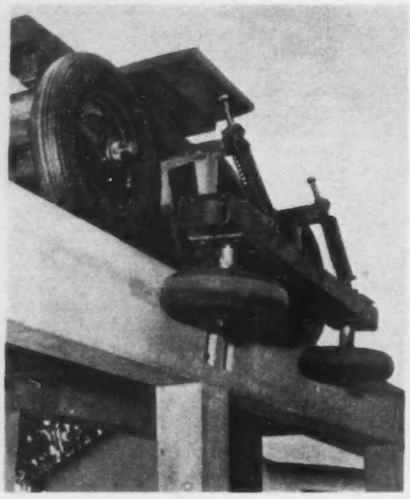
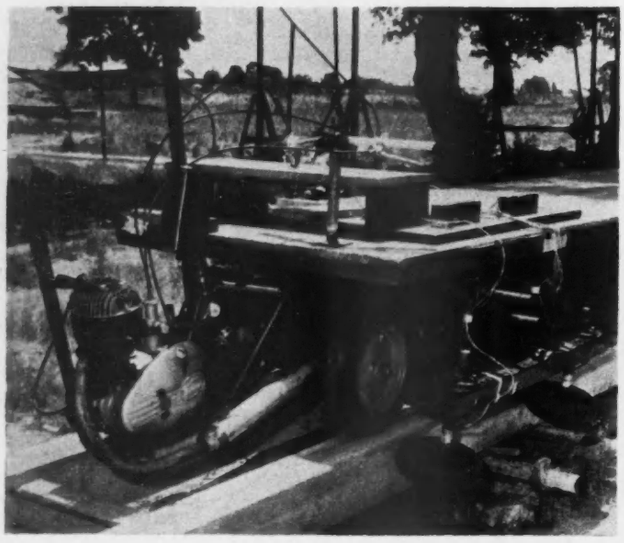


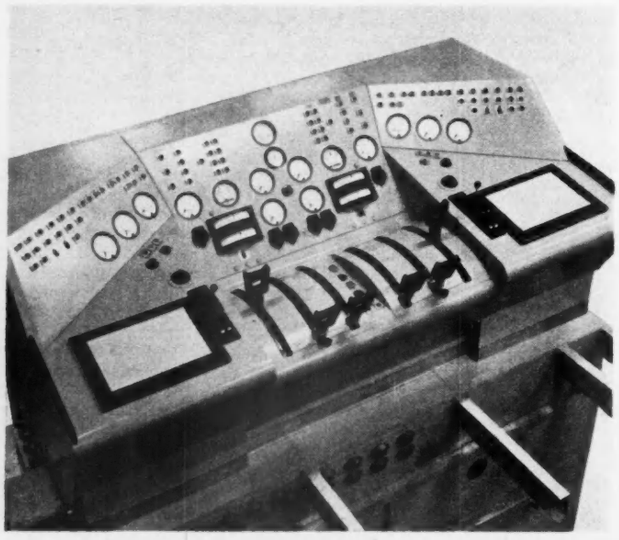
Fig. 6 Stresses in 4-leaf equivalent.

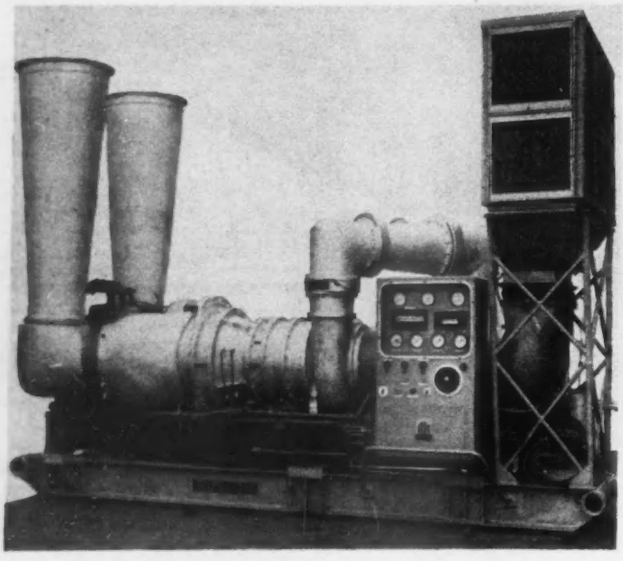


(*Above and below*) *Model of a silent train designed in Southern Rhodesia. Its rubber tyres and guide wheels run on a concrete track. Known as the Skyway, its design speed will be 50 m.p.h.*

Mock-up of the Vickers VC10 seating arrangement shows six passengers abreast in the 150 seat layout. This contender for medium and long-haul jet transport is beginning to take shape at the Weybridge works.







(*Above right*) *AEI control console for the propulsion machinery of the P and O liner Canberra.*

(*Left*) *Ruston and Hornsby gas-turbine delivered to Iranian Oil Services Limited for pumping crude oil.*

(*Right*) *An aluminium casting is used by Vacuum Research Limited for this vacuum valve.*

Marketing

Engineering Centre Exhibitors

Five new companies have become permanent exhibitors at the Birmingham Engineering Centre.

They are, N. HINGLEY & SONS (Netherton), steel manufacturers and forgers;

LONDON FAN & MOTOR, electric fans, motors and regulators;

DARGUE BROTHERS, drafting machines, drawing office furniture and equipment;

ARMSTRONG PATENTS, hydraulic actuating equipment for remote control of valves, windows and louvres, and

BRITISH ERMATO corporation, SIMPLIFIX COUPLINGS, high pressure valves, hoses and couplings (Ermeto), high pressure couplings (Simplifix).

Swiss Buy USSR Helicopter

Commercial competition for the British helicopter is normally thought to throw its shadow from across the Atlantic. Now the Soviet Union has entered the field, selling to an Austrian-Swiss hotel syndicate an 11-seat Mil Mi-4 helicopter for a price equivalent to almost £90,000. The syndicate receive with the Mi-4 two sets of spares, crew training course and after-sales service.

A Soviet helicopter, carrying winter sporting executives about the resorts, will be a practical advertisement in a highly significant spot—and at a very reasonable price.

de Havilland Down Under

While their head offices handle Mr. Sandy's mergers, the air companies are active about the world. In Australia, DE HAVILLAND AIRCRAFT PROPRIETARY are to take control at Lidcombe, Sydney, of the government's engine factory.

The factory will be taken over as a going concern and employees who want to will stay on as de Havilland workers.

The Lidcombe factory will, under an agreement with the Australian defence department, continue to work on defence projects and will also engage in commercial operations. The history of the plant is that it was put up in the Second World War and has recently been repairing and overhauling Double-Mamba turboprop engines for the Navy and ROVER Meteor engines for the Army.

Copper Wire £8 Million Contract

The electrification drive pursued by the Chinese government has led to an £8 million contract for copper rods being placed with a group of United Kingdom firms.

The order is worth four times the total of British copper exports to China (£2,100,000) in the whole of 1959 up to the end of November.

Placed by the China National Metals Import Corporation the group handling the contract includes: BRITISH INSULATED CALLENDER'S CABLES, ENFIELD ROLLING MILLS, RICHARD JOHNSON AND NEPHEW, PIRELLI and FREDERICK SMITH AND COMPANY.

Delivery of the copper rods is expected to be completed during this year. Despite the exclusion of China from the British Government's trade liberalisation steps of last year, so large an order early in January suggests that 1960 may see a reversal of the 1959 trend in which British exports to China fell below the 1958 level.

Dowty and the Little Ships

DOWTY MARINE, a company of the DOWTY GROUP, have made an astute move in appointing the newsworthy Mr. Donald Campbell as managing director.

The proud or prospective small boat owner may have no yearning to rush noisily up and down the more beautiful of England's few lakes but an association of speed and gaiety will not be unwelcome on the sales side.

With their ambitious, and convenient, water-jet propelled Turbocraft, and now with Donald Campbell at the helm, Dowty Marine appear set to go ahead as fast as anybody in the fast growing small boat market in Britain.

Apart from the commercially cheering achievement of selling their entire 1960 output in the first week of the year, many of the firms taking part in the 1960 Boat Show at Earls Court, London, will have noted that the attendance was 50 per cent up on last year's show.

At the other end of the social scale from trudging round Earls Court the membership of the Royal Yachting Association has risen almost as remarkably—from 6,667 a little over a year ago to 9,200 now.

The makers of small pleasure craft, yachts and cruisers have a business of a few million pounds a year at the moment. As the call of the open road disappears under six, seven or eight million cars, the call of the open water may well lift that figure many times.

Loch Ericht Power Station

Contracts for a new power station on the banks of Loch Ericht, ten miles from Dalwhinnie, Scotland, have been awarded by the NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD. The new station will stand at the outlet of the tunnel from Loch Garry to Loch Ericht, part of the Rannoch section of the Grampian power scheme.

There is a maximum difference in level between the lochs of 196 ft.

A. A. STUART AND SON (GLASGOW) have the contract for building the station, which will produce 10·3 million units a year; they will also be responsible for the allied civil engineering work. The 2,200 kW turbo-induction generator is to be supplied by BRUCE PEEBLES AND COMPANY, of Edinburgh. The ARMFIELD HYDRAULIC ENGINEERING company will make the turbine.

SIR ALEXANDER GIBB AND PARTNERS are the civil engineering consultants.

First 275 kV Switchgear in Scotland

A. REYROLLE, of Hebburn, Co. Durham, are to make the first 275 kV switchgear installation to be used in Scotland for the South of Scotland Electricity Board. It is to be used at a substation near Strathaven, as the first provided for the supergrid linking the main generators and load centres. The switchgear has to be in use by the spring of 1962 when COLVILLES' new strip mill will be making heavy current demands.

For the Central Electricity Generating Board Reyrolle have a contract for the 132 kV switchgear required at Richborough, two miles from Sandwich on the Kent coast. In this case, because of its closeness to the sea, the switchgear will be housed in a building.

January Export Guide

The GENERAL ELECTRIC'S *GEC Export Guide* for January draws a challenging picture of the export markets. Twenty-six of the countries listed are in the "good" prospects category, nine in "improving," and only two are actually deteriorating—Iraq and Venezuela.

The good include among them Australia, West Germany, Ghana, and the USSR, but not China. The improving are Kenya, New Zealand, Spain and South Africa, and five others who were also in the "improving" section last October: Argentina, Belgium, Finland, France and Pakistan. There is no reason for unbridled optimism in the prevalence of the good and the improving. Its import is rather that the going is equally good for our overseas competitors.

The *Export Guide* examines in brief detail the changing trade position of the United States. More and more dependent upon foreign supplies as her rapid rate of consumption uses up home raw materials, the United States is losing the advantages of being a major exporter of basic materials.

Since the war America has poured out £25,000 million in foreign aid, plus £1,200 million in contributions to the World Bank, the international monetary fund and the international development organisation. In 1959 alone the final figure of the United States foreign aid and investment abroad is expected, says the *Export Guide*, to have been £1,600 million which, if no steps are taken, could reduce the nation's gold reserves below the level of her short term foreign liabilities. Despite this position President Eisenhower is opposing the serious attempt in Washington to reduce the level of overseas aid.

On American export competition the *Export Guide* makes the surely short term point that Britain's removal of dollar import restrictions last autumn does not spell immediate improvement for American sales in this country. More generally GEC's economists point out that winning a place in markets where others have had time to build up their connections may require aggressive methods. The short (American) rejoinder to this is that the consumer is king and mighty changeable at that.

Canada

The Canadian economy, now in a state of optimism and potential boom after last year's uncertainty is not showing strong recovery in investment, exports or construction. For our heavy engineering exporters this is not good news but when things pick up for them in Canada presumably the roundabout to that particular swing will be that Canadian exports will also improve.

Mr. Diefenbaker's enthusiasm on the subject of increasing British exports to Canada has not been rewarded, partly due to indifferent sales techniques by United Kingdom firms, but also because there has been a movement towards closer Canada-US trade relations.

Swan Hunter Speed

Forty-two weeks from the keel laying to the sailing of the Horin Palm for her acceptance trials is a record for the Walker shipyard of SWAN HUNTER and an indication of what they can do now that several million pounds have been spent on modernisation.

Not a complete indication because the 8,550 ton cargo carrier was being built while the modernisation was being carried through.

Sheerness and Gillingham plants

The process of industrialising the Thames estuary coast has a long way to go and it is going quite rapidly.

PYE have announced negotiations to buy 50,000 sq. ft of factory buildings in Sheerness dockyard. If all goes well the company hope to begin occupation next month. Naval communication equipment, high fidelity sound reproducers, electro-medical equipment, and test instruments for electronics applications are to be made there.

At Gillingham, BOWATER-EBURITE Packaging has paid £211,000 for 18 acres of land and is to build a plant, starting construction before this summer. It is intended to manufacture flexible packaging materials

Expansion in Hydraulics

With the increased demand for machine tools and for tractors and earth moving equipment has come a greater call for hydraulic components.

S.A.V. HYDRAULICS, who also make such components for mechanical handling equipment, vehicles and other machinery, are enlarging two works in order to meet the demand. 10,000 sq. ft additions to the productive floor space of factories at Chessington, Surrey, and Bedhampton, Hants, are being made.

The company's growth in the last two years has included the opening of offices in Birmingham, Leeds, Manchester and Glasgow. S.A.V. (Stein Atkinson Vickers Hydraulics Limited) are the British makers and distributors of VICKERS DETROIT hydraulic components.

Napier in South-East Asia

Engine adviser to the Burmese Navy is not a post that appears in any official list, but it would cover part of the new appointment made by NAPIER, one of the ENGLISH ELECTRIC companies.

Appointing a resident technical representative in South-East Asia, Napier have assigned to Mr. F. J. Cox an enormous territory which takes in Burma, Borneo, Indonesia, the Federation of Malaya, Singapore and Thailand. Mr. Cox's main function will be to give advice on company products to Napier agents in South-East Asia, and his connection with the Burmese Navy will be to advise on the operation and maintenance of their Deltic engines.

Cavitation Erosion: Comparative Tests

By R. Mathieson, B.Sc., Ph.D., and J. M. Hobbs, B.Sc., Ph.D.

Manchester University

Research into cavitation erosion is being carried out in many laboratories throughout the world. Very often there is a notable lack of agreement between the results obtained at different centres.

While there has been for many years a continuous and increasing effort by research workers on the problem of cavitation erosion, the results from different sources are seldom directly comparable, a feature which is not entirely confined to tests of radically differing form. This is explained to some extent by the complexity of the problem and the disturbing way in which a small change in test conditions may produce markedly different results. There is also the fact that, except in the case of the magnetostrictive vibratory apparatus,[1] no standard conditions for tests have yet been evolved.

This article presents the general results of some recent work at Manchester University, where originally it was intended to undertake comparative erosion tests on a range of materials with specimens from the same batch, being tested by the three methods most commonly employed: viz. (*a*) in a constricted tube, (*b*) drop-impact, (*c*) vibratory. However, the equipment for method (*c*) had not yet been completed and the report is concerned with tests by methods (*a*) and (*b*) together with some non-comparative tests by method (*a*).

These two methods are of interest; the first because it is generally conceded that the constricted tube test can be made to simulate most closely cavitation conditions obtained in practice, although a relatively long exposure of several hours is required to obtain measurable erosion. The second, drop-impact test, produces erosion in a short time (a few minutes), but hardly pertains to natural flow conditions, except perhaps for machines such as the Pelton wheel.

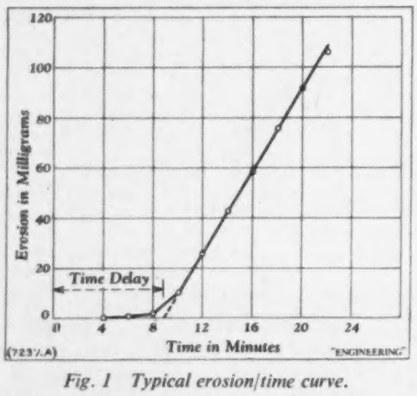


Fig. 1 Typical erosion/time curve.

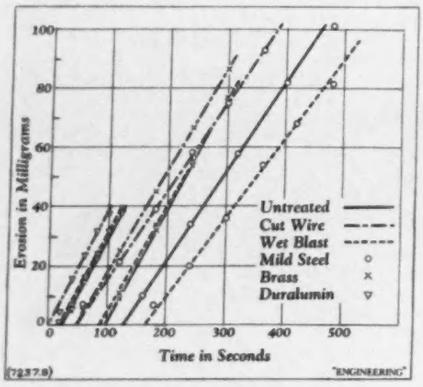


Fig. 2 Effect of shot peening.

DROP-IMPACT TESTS

The machine developed was of the type used by de Haller[2] and comprised an encased light alloy disc 12 in in diameter, which was driven electrically and capable of peripheral speeds of up to 850 ft per sec. The specimens, tested in pairs, were screwed into the rim leaving a projection $\frac{1}{2}$ in long and $\frac{1}{4}$ in square in section. On rotation these cut through two jets of liquid under a head of 70 ft from $\frac{1}{16}$ in diameter nozzles arranged diametrically with respect to the disc. The erosion was measured by accurately weighing cleaned and dried specimens. By plotting erosion versus time, curves as in Fig. 1 are obtained which show a time delay before erosion commences followed by a near linear rate of erosion with, in some cases, a small transition zone in between.

Dynamically the factors of most importance in this test are the impact velocity, the jet diameter and the density of the test fluid. Initial tests made on mild steel, brass and duralumin specimens established that the rate of erosion was proportional to the fifth power of the impact velocity, over the working range of speeds, to the square of the jet diameter and to a power of the test fluid (neutral) density approaching two. Thus, using water as a standard fluid, tests on this type of machine could be reduced to some standard velocity and jet diameter such as 750 ft per sec and $\frac{1}{16}$ in respectively, provided specimens were $\frac{1}{4}$ in wide.

The time delay was also affected by the impact velocity to a power which varied from about four for steel to nearly six for brass and duralumin. As the time delay is also affected by initial surface roughness, its conversion to a standard velocity condition is impracticable unless the roughness is specified.

A report that shot peening improved the fatigue resistance of metals led to vibratory type erosion tests by Grossman[3] which showed a noticeable improvement in erosion resistance for shot peened ferrous and non-ferrous metals. Corresponding tests with mild steel, brass and duralumin shot peened and untreated specimens on the drop impact machine have shown practically no change in the rate of erosion, but the time delay was adversely affected. (The peening was carried out with 0·022 in diameter cut wire.) However, specimens which had been blasted with water-borne particles showed a slight increase in the time delay periods, which varied slightly with different abrasives; the erosion rate was not affected. With duralumin, both treatments adversely affected the time delay. Fig. 2 shows a few examples. Fig. 3 shows the effect on mild steel when quenched from dull red heat and also when case hardened before testing. The second treatment gives a pronounced increase in time delay and also improves the rate of erosion, while quenching achieves a smaller increase in time delay only.

Tests with electrolytic and non-electrolytic fluids produced surprising results which seem to indicate that the erosion by the drop-impact machine is not necessarily a purely mechanical action. Brass specimens tested with paraffin, water and carbon tetrachloride showed a variation of rate of erosion with density to the power 1·7, with little effect on time delay. Mild steel eroded at similar rates with water and carbon tetrachloride despite the different densities, suggesting a corrosion effect.

Using solutions of potassium carbonate on both mild steel and brass gave an almost linear increase in erosion of some 270 per cent for steel and 350 per cent for brass with an increase in specific gravity of the solution from 1 (water) to 1·4 (see Fig. 4). The time delay was also reduced in both cases for increased concentrations. These effects cannot be entirely accounted for by increased density.

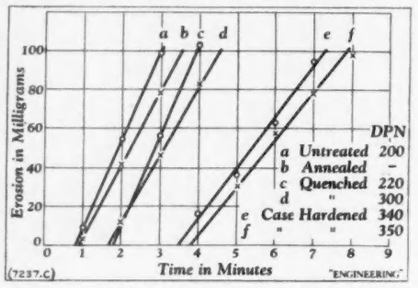


Fig. 3 Effect of heat treatment on erosion.

A synthesised sea water was used to erode several materials with no noticeable effect on metals of the brass group, but with a slightly adverse effect on both time delay and rate of erosion for metals such as cast iron, carbon steel, inconel and nimonic 75.

These tests using different fluids have been somewhat exploratory and obviously the whole question of working fluid influence needs much

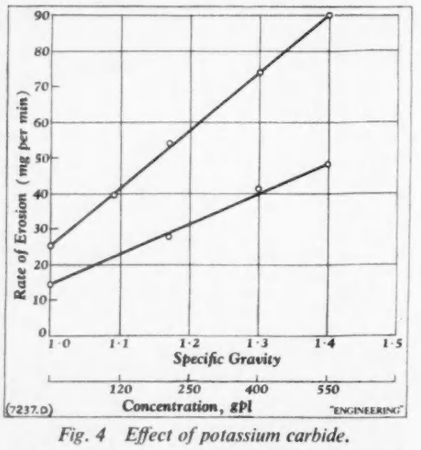


Fig. 4 Effect of potassium carbide.

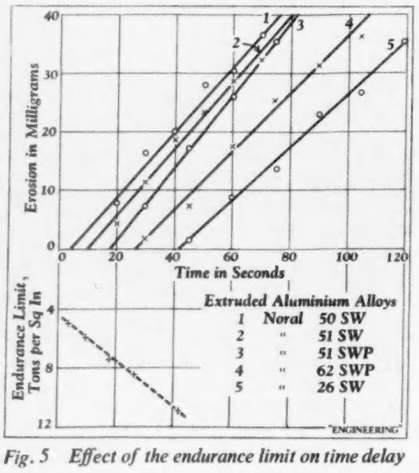


Fig. 5 Effect of the endurance limit on time delay

further investigation if any progress is to be made in differentiating between mechanical, chemical and electrolytic effects.

The remainder of the work carried out with the impact machine was intended for comparison with tests on specimens of the same composition by the flow method. These supported in general the belief that hardness and strength of a metal is the best guide to its erosion resistance (see Table). Where details of the fatigue properties of the materials were known, the differences in behaviour were examined and it was found that the delay period was directly related to the endurance limit, as shown in Fig. 5 (also observed by Leith[4], using the vibratory test).

TABLE.—*Relative Erosion*

Material	Drop-impact	Flow	Kerr's* Vibratory	Hardness V.P.N.	U T S
Aluminium bronze (standard) (1) (2) (3)	1	1 0·86 0·83	1	180	44
Stainless steel (1) (2)	1·39	0·95 1·45	1·35	200	—
Mild steel ..	1·44	1·45	—	200	35
Manganese bronze (1) (2)	2·17	1·29 1·83	2·49	140	34
Brass (1) (2)	2·41	3·88 3·18	5·08	130	30
Duralumin (1) (2) (3) (4)	2·47	5·24 4·31 4·13 3·6		140	21
B A 305 W P (1) (2)	2·84	4·91 4·92		155	30
B A 28 (1) (2)	3·74	6·08 5·65		80	17
B A 21 (1) (2)	4·62	6·93 7·25		67	12
99·5 per cent aluminium (1) (2)	5·00	3·09 2·49		33	5
Cast iron (1) (2)	11·85	20·9 17·5		220	—
Perspex ..	26·8	2·76		—	—

Figures for drop-impact test are the mean for at least six test pieces. Those for the flow test are individual values. Water temperature and air content in the flow test were 41° C and 1·0 per cent respectively.

* The figures in this column were taken from a paper by Leith,[4] published by the Engineering Institute of Canada.

FLOW TESTS

The flow type of cavitation test was carried out in a small water tunnel, with throat speeds of up to 100 ft per sec. The working section was rectangular and, after considerable experiment, it was found that a circular cylinder of diameter approximately 75 per cent of the tunnel height gave intense cavitation clouds and produced measurable erosion after several hours running. Damage occurred in two main zones. The first was located on each side of the cylinder just downstream of the minimum section and the second was located on the tunnel walls about 1·75 cylinder diameters from the centre of the cylinder.

The test conditions for maximum erosion on the wall and the cylinder were different and the rate of erosion diminished considerably for conditions other than the optimum. In addition to being affected by the geometry of the working section and the pressure distribution, the damage was least with cold air-saturated water. A typical erosion test by this method gives a relatively small time delay compared with the drop-impact test, and it is therefore proposed to refer only to rate of erosion values, these being practically constant.

COMPARISON OF TEST RESULTS

To permit comparison of the relative rates of erosion to be obtained by the two test methods, the scheme adopted is that of taking one material as a standard and using the ratio of the rates of erosion of the other materials to that standard.

The table, in which aluminium bronze has been used as a standard, shows qualitative agreement for nearly all the other materials; but there are considerable numerical differences in many cases. It is difficult to account for the larger differences when in the case of mild steel and stainless steel there is quite a good agreement.

In order to examine the possible similarity in the relative rates of erosion by methods (*a*) and (*b*) with those given by method (*c*), results obtained by Kerr[5] for a few similar materials are tabulated in the third column. Only qualitative agreement is found in all cases although some are in quantitative agreement also.

It is hoped that the results of this research, although incomplete, form a useful contribution to the subject and may perhaps point the way to further work both in Manchester and elsewhere, so that answers to the many still outstanding questions may be forthcoming.

In conclusion it may be added that the composition and state of most of the large numbers of specimens already tested is available upon request, and many thanks are due to those firms who supplied samples of material from which the test pieces were made.

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[4] W. C. Leith, "Cavitation Damage of Metals," The Engineering Institute of Canada *Journal*, p. 43, March 1959.

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Timetable Compiled for Interplanetary Travel

A combined celestial road map and timetable, which will provide almost instantaneous readings of optimum departure and arrival times for trips to other planets, has been devised. This handy reference chart is said to make it as easy to plan a trip to Mars as to work out the details for a cross-country bus trip. The chart is described in a paper presented to the American Rocket Society by scientists from the Lockheed Missiles and Space Division. It shows trajectories and associated velocities required to leave Earth on any particular date for a trip to Mars, and the number of days it would take.

"By employing a high speed computer to fabricate the combined solutions," it is said, "literally thousands of orbits per hour may be calculated and their parameters presented in standardised charts and tables for the various solar planets." The system was described as a way of "mass producing data from which one can make intelligent selections of orbits for interplanetary missions." The cost of calculations is said to work out to about 4*d* per orbit.

Workers at Lockheeds in the USA have calculated about 40,000 trajectories for random periods for both Mars and Venus. The potential cosmic trajectories are arrayed on a graph similar to a topographic contour map.

A hypothetical case, quoted in the paper, involves a two-man expedition to Mars. Timings for the trip include arrangements for a landing by one of the astronauts who, after ten days, would be picked up for the return trip.

Pulsed Neutron Source for Reactor Research

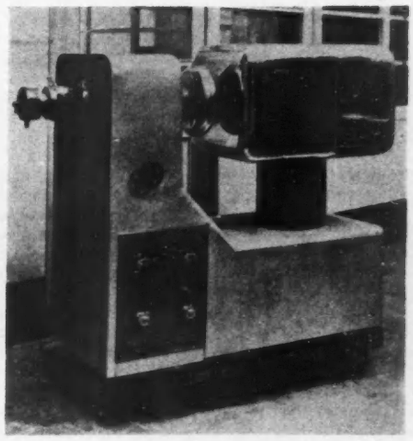
An accelerator which can supply a current of hydrogen ions of up to 1 mA with an energy of 150 kV is being marketed by Miles Highvolt Limited, Mortimer Road, Hove, Sussex. When used in conjunction with a suitable target such as deuterium or tritium, it becomes a source of neutrons with a maximum intensity of 10^9 neutrons per second (D/T reaction). Such a neutron source has many outstanding advantages, the most important of which is that the source can be switched on and off electrically.

Until quite recently neutron sources have been mainly in the form of radioactive substances, which of course have a continuous output characteristic. They also have other disadvantages such as the fact that they cannot be switched off when not required and are therefore a continual hazard wherever they are used. Furthermore, radioactive materials with short half lives need frequent re-irradiation; an impossible task in countries where irradiation facilities do not exist, and a difficult and costly one in countries where such facilities do exist.

A neutron generator of the type now being marketed by Miles Highvolt Limited is not only capable of supplying a pulsed beam of neutrons, but it can be switched off, so that there is absolutely no radiation hazard when it is not in use. When it is in use, the accelerator is said to emit no penetrating gamma radiation, and only a small quantity of low energy X-rays, which can be absorbed conveniently by a thin lead screen.

A pulsed neutron source can be used in conjunction with a sub-critical assembly to study many of the important parameters of a nuclear reactor. With a steady source of neutrons, the steady-state performance of a reactor can be studied and same of the necessary parameters for the arrangement of fuel rods and moderator characteristics can be made. However, when a pulsed source is used, the all important dynamic characteristics of the reactor can be predicted. These time-dependent phenomena are extremely important in reactor design and cannot be studied with the steady-state methods previously available.

By itself, the Miles Highvolt accelerator may be used to study the properties of moderator materials; for instance, migration length and the effects of temperature and impurities can be studied. With graphite moderated reactors, the control of graphite impurities is important, and the accelerator could also be used for this.



The SAMES/Miles Highvolt 150 kV accelerator makes an effective pulsed neutron source which has many applications in reactor research.

Instruments and Electronics

The past year has been marked by a much greater rise in output of domestic radio and television equipment than had been anticipated. At the same time production of both instruments of all types and of industrial electronic equipment continued to gain in importance. Exports of instruments and electronic equipment (other than domestic receivers) now probably total more than £40 million a year.

With the rapidly approaching saturation of the market for "first" television sets, there is likely to be a steady transfer of emphasis in the industry from domestic to industrial equipment, while progress towards automation should stimulate the production of instruments and electronic equipment alike.

Exports

Broadly speaking, exports of instruments have followed the same trend as total output, though there have been rather wide fluctuations from month to month. Over the fields considered by the Board of Trade enquiry, exports account for about 25 per cent of total output and in 1958 accounted for a total of £18,781,000.

The exports of instruments were, therefore, roughly comparable with those of radio communication, navigational aids and radar equipment. These showed a considerable recovery in 1959 reaching an estimated figure of £18·5 million based on the first nine months. Exports in this category had declined to just over £14·5 million in 1958.

At the present time, exports of television sets form a very small proportion of total output. In 1958 export sales amounted to a monthly average of 2,000 sets as opposed to 168,000 home sales. The main obstacle to exports is, of course, the British standardisation on 405-line transmission. There has been growing pressure from the industry for some time for the adoption of the continental 625-line transmission which would enable manufacturers to produce the same set both for home and export markets. It must be recognised, of course, that the introduction of this system would lead to difficulties for some five to seven years and that for this period, it would almost certainly be necessary for British broadcasts to be sent out on both systems. However, there can be little doubt that in the long run, the adoption of the 625-line system would result both in greatly increased exports and in better product for the home consumer.

In the export field, increasing competition will, undoubtedly, be felt both in the electronics field and in instrumentation from the Japanese industry. Early in 1959, it was announced that Japanese production of electrical measuring instruments in 1957 totalled $20 million and it was hoped that an output of as much as $180 million could be achieved by 1962. At the same time, it was announced that the Japanese were aiming to export an increasing amount of scientific and industrial control instruments.

The Japanese are of course, already well established in the export of radio equipment and more recently of transistors. The domestic radio field represents the first impact of Japanese electronics on the British home market. A factory has been established in Ireland for the assembly of radio receivers using Japanese transistors and otherwise British components. This device will enable receivers to be imported into the UK at prices below those possible to home producers due to the lower price of Japanese transistors. Initially, this will probably not present much of a threat to British producers but production is expected to rise after three years to about 250,000 sets per year. It was stated at the time this factory was announced that sets would retail in export markets at prices comparable with those charged for sets locally manufactured. On the other hand, the lower price of components and probably labour would obviously allow considerably lower prices. The assembly of these sets in Ireland will allow imports into the UK without restriction.

Manpower

Official employment figures for the instrument and electronic industries as a whole are not available. The available figures for the domestic side of the electronic industry suggest, as would be expected, a continuous and steady rise in numbers employed over the past few years, with the single exception of 1956. The numbers employed in the manufacture of "wireless apparatus, gramophones, valves and lamps" has risen from 102,300 in 1948 to 208,800 in September, 1959.

Whether this growth will continue will depend on two main factors. In the first place, it remains to be seen what degree of contraction takes place in the radio and television industry once the initial market is saturated. As against this, a rapid growth in the industrial uses of electronic equipment can be expected. The effects of defence readjustments are harder to foresee. While the demand for aircraft electronics is likely in the long term to decline, this may be more than offset by the increasingly complex requirements for guided weapons.

Broadly speaking, it is probable that labour requirements for both instruments and electronics will continue to rise.

A feature of the radio and television industry in particular is the high proportion of female labour employed. In September of last year, for example, out of the 208,800 total figure given earlier, 101,500 were female. This may mean that whatever employment adjustments prove to be necessary, they will be more easily carried out than in industries such as shipbuilding and aircraft with predominantly male labour forces. Whatever the trends on the shop floor, however, a steadily increased flow of technicians and engineers is likely to be required.

Plant and Product

Up till the past year no figures have been available for the output of scientific and industrial investments in the UK. An obvious difficulty in compiling such statistics is the wide range of items involved and variety of industries responsible for their manufacture. Statistics were published by the Board of Trade for the first time in August of last year covering a variety of scientific and industrial instruments and apparatus.

The Board of Trade pointed out then that a substantial proportion of goods characteristically made in this industry is made by firms in other industries as a subsidiary activity; and in particular that many electronic instruments are made in the radio and other electronic apparatus industry. While there is obviously a possibility both of double counting and of a variety of instruments being ignored altogether, these statistics provide for the first time an index of the progress of the instrument manufacturing industry.

As the Board of Trade suggested when publishing these figures, the progress of this industry can be taken as a fairly good measure of progress in British industry towards automation. The figures go back to 1956 which has been taken as a base year. Taking 1956 as 100, the volume of deliveries corrected for price increases rose to 109 by 1958 and to 116 in the first quarter of 1959. This rise may be compared with an increase of 1 per cent in total manufacturing production between 1956 and 1958 and no net change in total industrial production over the same period.

Of the individual items listed, the most rapid increase has been shown by electronic computers (already discussed in this series under Office Machinery, 1 January, 1959). Production in 1957 was £3,745,000 while by the first quarter of 1959, output was at an annual rate of over £6½ million. The three most important catagories are industrial process measuring the control instruments, nautical, aeronautical and gunnery control instruments and a miscellaneous group including electronic measuring and testing instruments and nucleonic instruments. The first and last of these categories has continued to show an increase while, due to cutbacks in defence production, the second showed a slight decline between 1957 and 1958, which looked like continuing into 1959.

The electronics industry over the past few years has been marked by rapid growth of the more or less traditional domestic equipment and also by a parallel growth of the capital goods side of the industry. The latter, though still smaller in importance than the domestic field, has now grown sufficiently to be regarded as a separate industry in its own right. At the beginning of 1959, this growth was recognised by the cession of the Electronics Engineering Association from the Radio Industry Council. The Electronics Engineering Association covers manufacturers of communications equipment, radio and other navigational aids, electronic equipment for industry and the transmission side of the broadcasting industry. In many cases, of course, the same companies are involved and some basic items of equipment such as radio valves and transistors are common to both. However, the Electronics Engineering Association felt that the problems common to the two sides of the industry were becoming fewer.

The boom in domestic equipment has continued during the past year, both for radio receivers and television. Sales of radio sets in the first ten months of 1959 were over 1¼ million and nearly one fifth higher than the level of the corresponding period in 1958. The most remarkable increase, however, has been in the production of television sets. This has reached a level estimated at between 2·7 million and 2·8 million, about 800,000 more than in 1958. It is probable that retail sales have been appreciably lower than total production but even so, some authorities estimate that nearly 2·7 million sets may have been sold or rented. In spite of one of the finest summers on record, the seasonal drop in television set sales was less marked than usual. Whatever may be the position in 1960, it is clear that production and sales at this level cannot continue for very much longer.

Once the initial market for television sets has been met, it is probable that the annual demand will be in the region of one million to 1¼ million, depending on the length of service the average family expects from a set. This saturation point will probably be reached within the next one or two years and is now approaching much more rapidly than has been estimated in the past. Unless an appreciable export market can be built up, the radio and television industry will soon face the problem of considerable overcapacity.

By the end of 1959 there were an estimated 10 million television sets licensed; by the end of 1960 this will probably have risen to 11 million, and it is likely that the initial public demand, to all intents and purposes will have been met by 1961.

Present replacement demand is based on a life of about seven years, which would give an annual demand of at the most 1·6 million sets. There seems to be little likelihood of this figure being improved on; if anything, the average British buyer would be more inclined to hang on to his existing set for a longer period than this. Colour television appears still to lie several years ahead; larger screens than the most popular 17 in have so far made little impact on the

market. The 21 in units are expected to sell better during the coming year, largely due to the introduction of 110-degree tubes, and some authorities believe that they could account for as much as 20 per cent of sales by the end of 1960

Improvements in design appear unlikely, however, to influence the size of market very greatly, and manufacturers must probably reconcile themselves to an average sales figure in the region of 1·5 million.

The most significant trend in the electronics industry is the rapid growth in the use of semiconductor devices. UK production in 1959 continued to rise to an estimated figure just below 40 million units valued at about £45 million. Progress during 1960 is expected to be even more rapid and the total number of units produced is likely to exceed 65 million units valued at about £70 million. This, in fact, is a comparatively conservative estimate, some authorities inclining to the view that consumption will double every year for the next few years at least. These figures may be compared with an estimated 14 million units produced in 1956.

The leading country in the production of semiconductors is, of course, the United States, where between 140 and 150 million units were estimated to be produced in 1959. In the international field, however, the most significant rise in production has taken place in Japan. In 1958 Japan produced nearly 39 million units and in 1959 this has probably risen to about 85 million units. The Japanese industry was established largely with American know-how and plant and it is now able to export transistors to the United States at prices considerably below those of the US manufacturers.

The growth of the semi-conductor industry is now world-wide. Within a space of a little more than five years, the semi-conductor industry throughout the world has risen to a position of great importance. It has been estimated that about 125 companies in more than 16 countries are engaged in various aspects of the field—of which 79 are producing transistors, 103 producing diodes and rectifiers, and about 36 are engaged in production and development of the newer types of photosensitive device. Total world output of transistors alone was expected to reach about 100 million units in 1959.

One of the principal contrasts between the UK industry and the rapidly expanding Japanese industry is the emphasis placed on different markets. In the UK a considerable part of research effort has been directed towards development of high quality devices for the industrial, communications, radar and military uses. The eighteen companies in the field in the UK produce well over 600 product types. In Japan, the nine manufacturers have mainly concentrated on production for domestic equipment, and have developed mass production techniques which have led to a very rapid rate of expansion. This has also enabled Japanese transistors in particular to be sold at considerably lower prices than elsewhere; this, and a concentration on the mass production of transistorised portable radios, has enabled the export of the latter to many parts of the world, including particularly the USA. Increasing attention is, however, being paid in the USA to the development of fully automatic manufacturing and test methods.

In all fields a limiting factor on the rapid adoption of semi-conductors has been that of price. With larger scale production and improved methods, some marked price reductions have been possible during the past year; some reductions were as much as 50 per cent.

The rapid progress and expansion in the semiconductor field will have an increasing effect on the overall market for electronic equipment. In the first place, the greater reliability of transistors as compared with electronic valves should help to reduce the resistance of many potential users of industrial control equipment to the use of electronics. This should give a considerable boost to the adoption of electronic control equipment over the next few years. Secondly, the great reduction in size of components should upon up virtually new fields even in what is now "conventional" equipment. The use of transistors in television sets, for example, is now possible on a far wider scale than was once thought feasible. This, and the development of wide angle television tubes may make radical changes possible which could stimulate the replacement market.

In computers, the adoption of solid-state devices in place of valves makes both for cheapness, due partly to lack of cooling and special power supply requirements, and a very great reduction in space needed. Both of these should greatly stimulate computer sales.

Materials

Increasing use of semi-conductors is leading to rapidly growing demand for silicon and germanium of the appropriate grades. In the UK the General Chemicals Division of ICI announced in February of last year that they had begun the bulk production of semi-conductor grade silicon. Expansion was already under way at that time, and by the end of 1959, the company's plant had a capacity of 4,000 lb a year. This was more than sufficient to supply the UK demand. Further extensions will, however, be completed during the coming year which will more than double the output. This will result in a progessive lowering of cost, and also in the production of poly-crystalline rods of up to 2 ft length, which can be used without further processing in zone-refining equipment.

The demand for both germanium and pure silicon has been stimulated exclusively by the electronic and electrical industries, and it is likely that these industries will be virtually the sole outlet for them for many years to come.

Design

Space is becoming increasingly expensive in most of the places where electronic equipment is used and, largely for that reason, there is now a growing demand for miniaturisation. In the decade that has just ended, a considerable amount of energetic work has been directed toward new concepts of building electronic units; everything must be as small as possible and at the same time it must be suitable for automatic production. In addition to the natural evolutionary trend, military demands are hotting up the pace of miniaturisation still further.

Design simplicity and standardisation are two more factors which have now assumed a high degree of importance, particularly in view of the ever increasing complexity of electronic equipment. Many new components and techniques have arisen to encourage the systems designer in these aims but, in addition to this, component designers and manufacturers have themselves been paying attention to both simplicity and standardisation (although not enough to the latter).

Transistors, crystal diodes, printed circuits and encapsulation techniques are just some of the component manufacturers recent contributions to the overall aims of optimum design of equipment. Between them these new designs and techniques, ranging from the profundity of the transistor to the unsophisitcated simplicity of wrapped wire contacts, form the real background to the progress that is now being made in equipment design.

Although semiconductors have had the biggest impact on electronic equipment of any single development, the equipment designer who seeks higher performance and new functions has probably been helped more in recent years by developments that have been made in the field of non-metallic materials—known as ferrites. These materials have characteristics that are of great assistance to the designer, at frequencies right up to the highest that are in use. They can be used to effect improvements in amplification, information storage, the control of radio frequencies in waveguides, aerial design, inductance design, and so on.

The technique of producing ferrites for various applications has been a very profitable line of research and development in the past few years and basic understanding has improved a lot in that time. One of the most important of the more recent applications has been that of the ferromagnetic amplifier, which has been contributing to the solution of the microwave receiver sensitivity problem. Yet another notable application is that of the memory core. In the form of small ring of ferrite, it has exhibited a marked ability to obey instructions given in the form of timed electrical impulses.

Advances in electronics, even radical ones, occur so often and so swiftly, that it is impossible to prophesy the future with any degree of accuracy, except perhaps on the broadest terms. Therefore, taking the broad view, it can be said, with absolute certainly, that the next decade will see some minor, if not major, revolutions brought about by electronics in certain fields of engineering activity.

Research

During the 1950's all developments in electronics were eclipsed by the invention and development of the transistor and its related semiconductor devices. In instrumentation, control, communications, radar and many other fields, the semi-conductor is not only finding a place for itself but it is at the same time making highly significant improvements and occasionally opening up whole new fields of engineering; such as missile instrumentation, which would be hopelessly difficult without semiconductors.

The main advantages of semiconductor devices are their low weight and size, low power requirement, low heat output and good mechanical ruggedness. These combined features have made it possible to reduce the size and weight, and increase the reliability of many types of electronic equipment to a remarkable degree. During the past five years a great deal of communications, navigation and control equipment used in aircraft has been reduced to a fifth of its former size. The reduction in space has been even greater in equipment for use in guided missiles and artificial satellites. Further reductions of the order of 10 to 100 times seems possible in the light of new circuit concepts that are now being evolved.

For the flight testing of aircraft, new transistorised equipment are today being used which could not have been carried in aircraft a few years ago, because they would have weighed far too much. One such equipment, developed in the United Kingdom, contains 90 transistors (each the equivalent of a valve) in a unit weighing only 3½ lb.

Semiconductor research has been advancing very rapidly, on a broad front, for the past ten years and will no doubt continue to do so for some time to come. Developments are continuing in basic theory, materials, circuit techniques and manufacturing methods at an increasing rate. Although many problems are still outstanding, such as temperature and frequency limitations and the cost of production, they are being overcome swiftly and surely as intensive research continues throughout the world. For instance, it can be expected with some degree of confidence, that the high frequency limit of the diffused germanium transistor will eventually be increased to several thousand megacycles per second. There is also no fundamental reason why power transistors with collector dissipations approaching one kilowatt should not be achieved.

Many potentially useful devices have recently appeared on the horizon, such as the field effect transistor, the space charge limited device, the unipolar analogue transistor, the spacistor and new multiregion devices, each of which will be the subject of intensive research and development and some of which will no doubt come to fruition. With these and many other developments yet to come it is reasonable to suppose that, within the coming decade, semiconductors will not only have outstripped conventional valves in most of their applications but they will have opened up entirely new fields in both science and engineering.

Processing Machinery

The performance of the processing machinery industries is always a good guide to the health of the economy as a whole. Its products are used by a large number of companies manufacturing a wide range of consumer and intermediate goods whose fortunes move in line with those of the processing machinery industries. In this respect 1959 was on the whole a good year for manufacturers of processing machinery.

The table on page 141 gives a picture of exports in 1959 but there are few published figures of output for these industries durings the past year. Some indication of the trend of home demand can be obtained from statistics of output or the main process machinery using industries. Comparing September, 1959, with September, 1958, there were increases in output of food, drink, and tobacco (7 per cent): ferrous and non ferrous metals (10 per cent and 15 per cent respectively); chemicals and allied products (15 per cent); textiles (12 per cent); clothing and footwear (13 per cent); china and earthenware (11 per cent); glass (6 per cent); timber and furniture (15 per cent); paper, printing and publishing (8 per cent); and refinery throughput (17 per cent). The only fall in output shown by process industries was in the case of leather and leather goods (down by over 20 per cent).

The climate of demand at home for processing machinery was thus generally favourable in 1959, and although increases in output are seldom followed immediately by demand for new capital equipment, the increases referred to above look promising for manufacturers of processing machinery in 1960.

Manufacturers of compressors had a poor year in 1958, but although figures are not yet available for 1959, deliveries will probably show an upward trend as a result of increased government spending on roads and the general rise in industrial activity. Further increases in construction activity should benefit particularly sales of portable compressors used for pneumatic drills.

Pump manufacturers also had rather mixed fortunes in 1959, although it is impossible to generalise since many companies in this field specialise according to outlet, and there are usually marked differences between the experience of one company and another. Worthington-Simpson, for example, reported increased profits and sales in the year ending June, 1959, but anticipated strongly competitive conditions from companies whose main outlets are in the electricity supply industry. Pulsometer, on the other hand, reported a fall in profits for the year ended May, 1959, but anticipated a steady increase in demand for their pumps as industrial activity expands.

Exports

1959 was a year in which the USSR emerged as a dominant buyer of processing machinery. Despite the recent setback, when an American group secured a large contract for textile machinery in the face of a lower bid from Platt Brothers (Sales), Russia is now Britain's second largest customer for textile machinery, after India. Exports of textile machinery to Russia more than doubled in 1959 to about £2·5 million and Platts can at least find partial consolation in the fact that in recent years they alone have secured £14 million worth of orders from Russia. The Courtaulds group were outstandingly successful in Russia in 1959 when one of their subsidiaries, Prinex Limited, gained a £15 million contract for the supply of complete plants and technical processes for the manufacture of viscose rayon tyre cord, acrylic staple fibre and cellulose acetate yarn. Among other Russian contracts in this field was a £1 million order for tyre cord machinery from Platts and a £600,000 contract for textile machinery from Ernest Scragg and Sons Limited.

Russia is also becoming increasingly interested in other types of processing machinery, in line with its current policy of encouraging the consumer goods industries. Black-Clawson International Limited benefited from a £4 million order for two high-speed newsprint machines in 1959, while Vickers and Bookers have secured contracts valued at over £8 million for sugar beet plant. A synthetic rubber plant valued at £500,000 is to be supplied by John Dalglish, while in the field of chemical plant British performance has also been impressive. Vickers Armstrongs, for example, competing against Krupps, won a £2·25 million chemical plant contract in 1959 while among smaller orders was one secured by Kestner Evaporator and Engineering for a large spray drying plant for sodium sulphite, and an order for £650,000 worth of gas plant for P.G. Engineering.

Looking to the future in other fields, Mather and Platt anticipate obtaining between £3 and £4 million worth of orders from Russia for pumps and food processing machinery over the next few years.

While Russia was probably the outlet which attracted most interest in 1959, the Commonwealth continues to be the major market for manufacturers of processing machinery and will probably continue to be so for the foreseeable future. Two new paper mills are shortly to be set up in the Antipodes for example, and while the benefits for manufacturers of machinery will not be felt immediately, UK manufacturers should ultimately stand to benefit. A £2 million paper plant is planned for the South Island of New Zealand, while in Tasmania a pulp mill valued at £A1¼ million, with an initial capacity of 24,000 tons per annum, is scheduled for mid-1962. In 1960 plant and equipment valued at £1¼ million are to be purchased in Europe, principally in the UK by Assam Pulp Mills.

India will probably continue to be the major overseas outlet for textile machinery manufacturers. The Indian Government proposes to install 7,500 automatic looms over the next three years to modernise the country's cotton industry.

India also promises to be a grow marketing for other types of processing machinery as its economy expands. Emphasis has hitherto been on plant to produce capital goods (the increase in exports of steelworks machinery in 1959 was largely accounted for by deliveries to Durgapur) but later expansion is planned for consumer goods. In 1959, plans were announced for an £11 million synthetic rubber plant to be set up at Bareilly, U.P., by a Bombay company, Kilachand Devchand. At least part of the finance for this plant is to be supplied by British investment houses, and although American finance will cover most of the plant's capital requirements, UK manufacturers should stand to gain some orders.

Competition for overseas orders is however growing more intense, particularly from the USA and West Germany. American, German and French interests have made offers to finance the cost of machinery and construction of a synthetic rubber plant in Pernambuco, Brazil, for example, and so far as is known no British interest has been expressed in this project. German manufacturers of chemical plant also continue to be active particularly in India, Russia and the Middle East. In petrochemical and petroleum plant, Italy is rapidly becoming a formidable competitor, particularly in the Eastern European markets. Italian manufacturers have also been active in the Middle East. A Plastics Exhibition in Teheran opened in July, 1959, in connection with the project to establish a plastics factory, was organised entirely by Italian plastics manufacturers.

While some branches of the processing machinery industry are hopeful of increased trade as a result of the Common Market and the Free Trade Association, others are far from optimistic. Kimberley-Clark, who anticipate big orders for paper products in the European market for instance, have recently opened a new £1 million cellulose wadding mill at Aylesford and further developments by other companies in this field promise increased orders for some items of paper making machinery. On the other hand, the Executive Committee of the British Chemical Plant Manufacturers' Association expressed concern last year over increasing competition in the Common Market countries.

Representation at European trade fairs is always a useful spearhead for an intensive sales effort, and lively interest was shown in the British exhibits of food processing and chemical plant at the International Trade Fair held at Machevo, Holland, in October, 1959.

Manpower

Separate employment statistics are not available for the majority of the processing machinery industries. Employment in the production of textile machinery and accessories fell slightly from 52,500 in September, 1958, to 51,100 in September, 1959, but this latter figure represents a recovery from the low point reached during the summer of 1959 when employment fell below 50,000. Most of the other industries covered in this article are included in the categories "other non-electrical engineering" or "metal industries not elsewhere specified" though they account for only a relatively small part of the total employment in these two categories. In the first of them there was practically no change in employment last year, the figure for September, 1959, being 693,000 compared with 691,800 a year earlier. As with textile machinery, however, the later months of 1959 saw a steady improvement which is likely to continue during the current year. Employment in the metal industries not elsewhere specified rose from 236,100 in September, 1958, to 246,800 in the corresponding month of last year and here again there is a probability of a further rise this year.

Plant and Product

The chemical plant industry has in the past suffered from lack of collaboration between equipment manufacturers and this has been a decided drawback viewed in the light of the tendency for an increased demand for "package" deals overseas, which entail the provision of complete plants and processes. Despite the success of the chemical plant industry in Russia last year, for example, it has been suggested by the BCPMA that the industry would have been even more successful if they had been in a position to supply more complete plants. Experience and resources need to be combined, for while chemical engineering consultants can be employed in this country to coordinate ordering, their work is less well known abroad.

Some moves towards closer cooperation between manufacturers of chemical plant have been announced during 1959, one being the formation of Sunimac, a consortium of five leading British companies set up with a view to providing complete plant and equipment for sugar, chemical and other factories. More cooperation with overseas companies was also a feature of 1959, two examples being the link between the Simon-Carves subsidiary Chemical Engineers (Wilton) Limited, and Société Proabd (France) and the setting up of McKee Head Wrightson Limited in this country, by Head Wrightson and Company Limited and Arthur G. McKee of Cleveland, USA.

Chemical plant manufacturers on the Continent have also not been slow to combine. In 1959 three leading Belgian producers formed Genie Metallurgique et Chimique S.A. for constructing plants for the production of sulphuric acid, phosphate fertilisers and allied products, while in France a number of manufacturers have formed Etudes et Réalisations de

Projets Industriels. This is primarily an advisory body to deal with projects in the petroleum, chemical and petrochemical industries and (perhaps significantly) will recommend non-French processes where these are found to be more satisfactory.

Delivery of most items of processing machinery is relatively quick, although the position is still unsatisfactory in some items of chemical plant. Some concern has been expressed by the BCPMA and the position requires further examination although delivery dates have been improving. This should result in 1960 in greater cooperation between chemical plant manufacturers and users and the Association of British Chemical Manufacturers has expressed its willingness to help in this matter.

To a large extent this question is complicated by the wide variety of rather specialised products made by the process machinery industries and the corresponding variety of materials and skills employed. The industries have on the whole been free from labour troubles (apart from some redundancy in textile machinery).

Materials

While metals continue to be the dominant materials of construction for most items of process machinery, the relatively new materials are making inroads into the market for the traditional metals. In particular the use of plastics has been increasing significantly in recent years in the chemical plant field (with a corresponding benefit to manufacturers of plastic machinery). Stocks of plastic materials increased in 1959 at a rate slightly in excess of production so that in general the supply position should be relatively easy in 1960.

The use of plastics in pumps has also been increasing, particularly of the relatively expensive material polytetrafluorethylene (PTFE), the use of which is expanding in seals and packings. The supply position of this material, of which ICI hold a monopoly, is becoming easier and there may well be further price reductions in the new year. The use of rigid pvc piping is increasing in chemical and food plant, while that of high density polyethylene, rigid pvc and glass fibre reinforced polyester plastics is expanding rapidly in such items as process and cooling towers and storage tanks. The use of impervious graphite in pumps and heat exchangers increased slightly in 1959, but in the case of the latter item of equipment, glass, stainless steel and cast iron are still the most widely used materials of construction. 1960 may nevertheless see an increasing hold on the market by newer materials. Processing machinery covers an extremely wide field, for it includes iron, steel and non-ferrous plant, rolling mills, paper mills, food and a dozen and one other industries. Developments and trends in iron and steel and in the food industry will be concentrated on here.

TABLE—*Exports of Processing Machinery, January to September, 1959, compared with January to September, 1958.* (£1,000)

	January-September	
	1958	1959
Boilers and boiler house plant	13,985	11,141
Steelworks and non-ferrous metal machinery and equipment	6,242	11,880
Pumps	12,780	12,541
Paper and pulp-mill machinery, and machinery for paper manufacturers	4,405	5,884
Printing machines (including apparatus and appliances) and bookbinding machines	6,978	7,889
Laundry and dry-cleaning machinery, other than for textile finishing	5,762	5,666
Textile machinery	29,786	29,947
Sewing machines	7,935	8,066
Air and gas compressors and exhausters	4,222	4,988
Boot and shoe making and repairing machinery	1,006	1,008
Brick, tile, sanitary ware, cement block and pottery making, china clay and other ceramic making machinery	452	452
Centrifugal drying and separating machines n.e.s.	776	999
Condensers (not electric)	646	469
Food and drink preparation and sterilising machinery, n.e.s.	5,513	5,908
Furnace plant (non-electric)	2,343	4,335
Gas and chemical machinery	3,918	4,197
Glass working and glass making machinery	231	215
Hydraulic machinery, n.e.s.	785	693
Mineral oil refining machinery	1,194	1,096
Oil (other than mineral) extraction and refining machinery	487	548
Packing, packeting, bottling (including bottle washing), canning and labelling machinery	4,981	3,903
Plastics and rubber working machinery, n.e.s.	2,663	6,453
Presses, plastics moulding, other than tableting and pelleting	652	811
Tanning and leather working machinery (excluding boot and shoe-making and repairing machinery	295	304
Tobacco, cigarette and cigar-making machinery	2,966	2,766
Water softeners, water filters and water sterilising equipment	1,158	1,038
Total	122,167	133,197

Research

A quiet revolution is taking place in the art of steel making. One reason for this is that high quality imported ores are easier to get and oxygen (not air) is now blown at supersonic speed through the molten pig iron in the basic Bessemer converter. In any case, the method of air blowing could only be used when the phosphorus content of the pig iron lay between 1·6 and 2·0 per cent and the resulting steel always contained a high proportion of nitrogen, so that a soft steel was always liable to brittleness. Oxygen steel, on the other hand, has the advantages of low capital expenditure in the steel plant, a high speed of working and low operating costs, with a wider application range as regards phosphorus content. It also gives a steel with a very low nitrogen content. Oxygen steel is, in fact, now accepted as equivalent to open-hearth steel in many specifications.

New types of oxygen-making plant have been installed in (or alongside) a number of British steelworks and already a substantial quantity of tonnage (gaseous) oxygen is being used for steel making. Further plants are also being installed. Both the existing basic Bessemer plants at Corby and Ebbw Vale are now supplied with tonnage oxygen and are equipped to use either air or oxygen-steam blowing, according to the quality of steel required. The new Bessemer plant recently installed at the Abbey Works of the Steel Company of Wales is entirely oxygen-steam blown for the making of special dead-soft steels. The production of steel by oxygen-blown converters is increasing rapidly.

Another reason is that an entirely new process has come into operation so that existing open-hearth furnaces have been abandoned and replaced by electric hearth furnaces. The liquid pig iron from the blast furnace is transferred to a specially designed tilting furnace where it is subjected to a pre-refining operation by blowing with an oxygen lance. In this operation, practically all the impurities are removed from the pig iron before the refined metal is transferred to another electric arc furnace where it is further refined to steel of the highest quality.

Molten steel is usually cast into ingots which then have to be reheated before being rolled or forged to workable dimensions. Casting steel in continuous lengths avoids the intermediate ingot stage, but it is only since the war that the continuous casting process has been developed to the production stage.

The twin strand plant at Barrow Steel Works casts small billets, mainly 2 in square, at the rate of 220 to 360 in a minute. High yield, good quality and the relatively low capital cost of installation are some of the advantages of the process. In addition, large slabs up to 36 in wide by 5½ in thick and 9 in square blooms are being cast by similar methods. This is the first works (in this country) to depend on continuous casting for the bulk of its production.

The United Steel Company has installed plant for the production of medium width hot-rolled strip up to 18 in wide at Steel, Peech and Tozer, Rotherham. The new mill is designed for the hot rolling of mild steel, carbon and alloy steels from 4 to 18 in wide. There are two sections in the hot rolling mill, a roughing and a finishing section, the complete mill having been supplied, together with the furnace pushers, by the Loewy Engineering Company Limited, Bournemouth. Microphones and loudspeakers at strategic points throughout the building enable information to be transmitted rapidly, as is so necessary in high speed mill operation. This equipment is supplemented by teleprinters. Centralograph control, with recorders on the machines, enables a record to be kept of machine stoppages and their causes.

Then there is the cold brass strip rolling mill, built by W. H. A. Robertson of Bedford, and installed in the Birmingham works of D. F. Taylor and Company, which is fitted with automatic gauge control equipment developed by the Baldwin Instrument Company Limited. The mill is used for finishing brass strip up to 15 in wide, and down to 0·004 in thick, at rolling speeds up to 500 ft per min. The automatic gauge control maintains a constant check on the thickness of the strip passing from the rolls and automatically corrects variations greater than ± 0·0003 in. The gauge employs the radiations produced by a beta emitting radioactive source, Strontium 90.

Although practically all the world's output of iron comes from blast furnaces, there are other methods of reducing iron ore that may be used in the future and so transform the practice of iron making. Most of the pig iron produced from blast furnaces is made into steel, except that used in making iron castings. There is, however, much to be said for the production of steel direct from the iron ore, without having to pass through the pig iron stage. So far no process has been developed to the large-scale production stage but quite successful work has been done in a small way. Some of the proposed methods include: the so-called low shaft furnace which, as its name implies, is essentially a blast furnace with a very much reduced stack height. Its advantage is that a weaker coke and a smaller size of charge can be used, as compared with an orthodox blast furnace. Another method is the rotary kiln process, the best known being the Krupp-Renn. There is also the sponge iron process, sponge iron being the metallic product that results when iron ores are reduced without melting. It is made quite simply by heating a mixture of the ore and solid carbonaceous material. One sponge iron process developed in Mexico is the HyL; this uses natural gas or light hydrocarbons instead of coking coal.

The British food machinery industry covers equipment for the production of bread, biscuits, chocolate and flour confectionery for the treatment and processing of milk the processing of grain and the processing and canning of various foods. Developments in food technology have two main objects—a better and a cheaper product. Automation has already been introduced to the grain milling industry thanks to the development of flexible pneumatic and gravity conveyors, and the introduction of bulk transport and storage of finished flour. Automation is also spreading to the users of flour as, for example, in the system of bulk flour delivery coupled with pneumatic handling of grain, sugar and wholemeal, all with automatic weighing and pushbutton control.

The natural colour and form of vegetables in cans is now being retained by using an improved continuous sterilizer that substitutes water columns for transfer valves and so eliminates sudden changes in temperature and pressure. Manufactured by the Food Division of Mitchell Engineering Limited, Peterborough, and used extensively here, one such unit has just been installed in Canada. It is in the form of a W, the outer legs of which are filled with water to maintain the steam pressure at the centre. Filled cans are conveyed from the seamer at about 170° F to a preheater section where the temperature is raised to 185° F. The cans then pass through water at progressively increasing temperature so that they are only 5 or 10° F below that required for sterilization at the base of the leg, where they enter the steam sterilization compartment without encountering sudden changes in temperature or pressure.

Civil Engineering

Over the last year events have been moving quickly for civil engineering contractors, especially in the home market. There have been important changes in the pattern of demand for the civil engineers' many services. Furthermore, changes in mechanisation which have been coming gradually into operation over the last few years have yielded a bumper harvest in 1959. The opening of the M1 motorway in October, 1959 marked something of a technical breakthrough for the contractors' plant industry and its organisation. On the home front, 1960 could see positive decisions taken with regard to both the Channel Tunnel and the Victoria tube. And experience of last year's drought will cause water supply schemes to be put in hand.

In 1959 the value of constructional work carried out in Great Britain (to judge from the first three-quarters of the year) will probably have been between £1,430 million and £1,460 million for the year. We saw the end of the credit squeeze and the beginnings of increased investment by private industry (although this remained on a fairly modest scale throughout the year) but on the other hand the public sector was experiencing the effect of the cuts in capital investment programmes announced after the financial crisis in the autumn of 1957. The modest expansion on the one hand probably, therefore, offset the modest contraction on the other.

In 1960 the categories of civil engineering work likely to increase are public road construction, with the extensions to the motorway system being got underway, and commercial buildings and new hospitals. The categories likely to stay comparatively unchanged are power stations, railway modernisation (though improvement schemes in BTC docks and pre-electrification work will continue to increase) and building renovations including slum clearance (these last in the sense of major modifications and site clearance). In open-cast coal operations and airfield construction, the volume of work will certainly be reduced. On balance the home market should see a significant but not sensational expansion in the demand for the services of the civil engineering industry in 1960, an interesting innovation possibly being the construction of roads along disused railway routes that may well be seen in Norfolk. Political gossip suggests that the number of new houses may well rise again above 300,000.

Exports

Since the war this country has rebuilt its turnover on foreign civil engineering contracts to a figure of £119 million in the year ended March, 1958, and even in the year ended March, 1959, when a large number of primary producing areas were suffering from the effects of the world recession, the figure of new contracts won by United Kingdom contractors fell only to £115 million. Markets which have stayed significantly buoyant have been Canada and India, and there has been no lessening of the volume of work in East and West Africa.

Prospects in the export market in general are good. 1960 should see the beneficial effects of a recovery in the purchasing power of the underdeveloped areas and contractors can look forward to doing rather better than last year and perhaps even exceeding the figures achieved in 1958.

With the New Year, the Association of Consulting Engineers published their annual brochure listing the work being undertaken by British consulting engineers in the 60 or 70 countries in which they are currently engaged overseas.

Outstanding as a single project is Kariba, where the Zambesi has been successfully dammed and the first of six 100 MW turbogenerators has just been brought into operation. The Queen Mother is going to officially inaugurate the scheme in early summer. Although British civil contractors did not have the main dam contract, they did have many of the specialist subcontracts and British firms are providing the lion's share of the electrical and mechanical plant. Altogether the consultant's responsibilities, shared primarily between Sir Alexander Gibb and Merz and McLellan (in conjunction with French partners) amount to nearly £60 million.

Harbour works in hand are currently worth around £70 million, with particularly large works at Calcutta and Bombay. In Kuwait, Wimpey are building a new jetty valued at £7 million for supertankers and Frederick Snow and Partners have begun designs for the new international airport there, estimated to cost £6 million. Though rarely on such a scale as these works, British consultants are also looking after a large number of drainage and sewerage schemes and water supply projects, and contracts for a number of these jobs will be let during 1960. Now that the Auckland Harbour bridge is complete no equally large bridge projects are left, but during 1960 Taylor Woodrow will be working on the bridge over the Niger, and Reed and Mallik in conjunction with Braithwaite have won the Hobart bridge in Tasmania, worth £A4¼ million, which was designed by G. Maunsell and Partners.

And so the list goes on. British consultants also have in hand preliminary investigations for a great number of projects including the Volta River works in Ghana and the Peace River development in Canada: Sir William Halcrow are looking at these two ventures and the mind boggles at their estimated value—£83 million (power development only) on the Volta and $442 million at Peace River. Nor is the catalogue lacking in smaller, but still very rewarding, schemes.

Representations continue to be made in official quarters that the present facilities for granting credit by UK contractors are inferior to those offered by some competitors. The point made is that conventional medium-term credit is an insufficient basis for the UK overseas contractor to achieve a really rapid and substantial increase in his turnover, since much of the work which could be obtained involves granting contractors' finance on a significant scale, a scale which is beyond the means of most contractors.

Not all work overseas is necessarily attractive. Some sections of the Middle East are particularly uneasy areas for the contractor. Nor are the offered methods of repayment entirely satisfactory. The Portuguese government attempted to interest British firms in the new bridge over the Tigris at Lisbon. It was proposed that the contractor built the bridge out of his own pocket and then re-couped himself by collecting tolls. Even the lucrative returns gained from most modern toll routes enticed no takers. The Portuguese are now to raise the capital from the World Bank.

Manpower

In 1959 the number of operatives employed on constructional work in Great Britain was running at a higher level than in 1958. In October, 1959, the total labour force was 1,082,000. Housing remained the most important sub-section, accounting for 610,000 workers last October.

On the management side interest continues in two outstanding problems. The first of these is to reduce the high accident rate on sites and the second is to apply, wherever conditions allow, some of the techniques of work study. The greater use of machines on sites increases the possibility of accidents. Increasingly managements are realising that systematic accident prevention from top management downwards, even though it consumes a certain amount of time, is a time-saver in the end for it reduces the number ofaccidents and therefore the hours which are lost not only by those who are injured by accidents but those who break off either to help anyone who is injured or merely to see what has happened.

Another problem which ought to be worrying management is the interest their tradesmen take—or do not take—in new developments. More than any other industry is there a failure to make new techniques and practices widely known.

Plant

The opening of the M1 motorway last year after a contract period of only 19 months was a triumph of mechanisation for the civil engineering industry. Never before had so much machinery of so large capacity been concentrated on one large job in such a way as to bring a new element of flexibility to the work. It enabled Laing's to meet the time schedule despite worse than average weather during the first 12 months. On the 53 miles of M1 built, £5 million of contractors' equipment was concentrated, or £100,000 worth per mile. Just before the Second World War the annual output of civil engineering equipment of all kinds was only £5 million a year. In 1954 it was £40 million and it has since increased substantially further.

So far as exports are concerned, in 1938 those for mechanical handling and excavating machinery were about £3 million. In 1958 they were almost £46 million and in 1959 are likely to have been between £48 million and £50 million. There is every indication that they will reach £50 million in 1960 as the capacity of the primary producing areas to press on with their capital development programme is enhanced by increased earnings from their own exports. Earthmoving equipment and cranes of every description, but especially tower cranes of medium height, will be in great demand.

The improved hydraulic systems on clearing plant have brought a wider range of tractor loaders, dozers and graders on to the market and have also improved the control of dumpers and pile drivers. Useful advances have also been developed on torque converters and fluid couplings. New compressed air equipment has made big improvements possible in the conveying of cement from central points and the cement bag seems to have disappeared for good.

There have, of course, been corresponding problems created by these developments. Large excavating machines are expensive to buy and must be kept fully employed all the time. The result has been a tendency for contractors to go increasingly into the hiring business with their own equipment and in turn to hire special equipment from other contractors or contractor hirers, and this competition is likely to intensify in the future. The possession of special equipment—say, a barge-mounted piling rig—is still likely to win a contract in the face of otherwise severe competition.

In the second quarter of 1959 monthly average deliveries of civil engineering contractors' plant, both in the home and export market, were £4·2 million compared with £3·6 million in the second quarter of 1958—an increase of 17 per cent. With the road programme building up to a peak in the next year or two there is no reason to suppose that the prospects of the plant manufacturers will be other than bright in 1960. Most of them will back themselves both ways by making mixers for concrete and "black top."

The only factor this year which would have a sudden and adverse effect on the prospects for plant manufacturers, and indeed for the civil engineering industry itself, would be an increase in the rate of interest. The civil engineering industry is always sensitive to changes from this source and the field of capital investment as a whole is probably more vulnerable to changes in the rate of interest than it has been at any time since before the Second World War.

Materials

1959 saw the commercial application of a number of interesting ideas on materials used in civil engineering. High-tensile steels were used in the construction on a scale greater than ever before. Another development in steel during the year was the introduction early in the year of pvc-coated steel by John Summers and Sons Limited. Also during the year came the introduction on a commercial scale of a silicone resin solution as a defence against damp.

Competition between steel and concrete has become intensified with the odds possibly moving further in the direction of reinforced concrete, though the year also saw, at last, the steel constructors awaken to the difficulties they were facing and begin a campaign to publicise structural steel. A paper, "The Economics of Frame Structures," given by Mr. L. R. Creasy to the Institution of Civil Engineers recently, indicated that the issue so far as first costs of multi-storey building frames are concerned has definitely gone in favour of concrete. He suggested that the difference in overall building costs may be as much as 25 per cent, though not all architects and engineers would accept a disparity of this size.

To some extent steel may be able to hit back with increasing production at Dorman Long's Lackenby Works which is now rolling universal beams in sizes of up to 36 in deep with maximum flange widths of 16½ in. This compares with the previous largest sizes of 24 in by 7½ in. In about three years the United Steel Companies will also have a mill making universal beams in operation at their Appleby-Frodingham works.

Both steel and concrete are going to have to meet greater competition from light alloys and from timber. Timber particularly, with "glulam" beams, structural plywood and a special contribution to conoid roof forms, is about to reach the position of a fully established structural material.

Another product which is becoming increasingly important commercially is supersulphate cement which is now being produced in this country at the rate of about 30,000 tons a year. This type of cement has a high degree of resistance to sulphate and other forms of chemical attack. Since 1955 a consortium has existed between Slag Aggregates at Scunthorpe (an associate of the United Steel Companies) and Balfour, Beatty and Company which has special interests in developing this type of cement for the Middle East. The consortium is particularly concerned with marketing cement based on Appleby-Frodingham slag.

Research

Civil engineering has frequently been instanced as an industry where the volume of research is exceptionally small. One much quoted figure is an expenditure on research of only 0·02 per cent of the annual turnover. In the last few years there has been a marked improvement. The Institution of Civil Engineers' research committees have been re-established, and nearly all the contracting firms now maintain a research division that undertakes something more than site tests. In addition a number of Department of Scientific and Industrial Research laboratories have major programmes of research on civil engineering topics, and most university engineering departments also have research in hand on civil work.

The research programmes being sponsored by the Institution of Civil Engineers covers arch dams, piled foundations, fatigue in structures and the behaviour of prestressed concrete under water. Work on arch dams is being mainly undertaken with the help of DSIR grants and investigations are being carried out at Imperial College in London and at the Universities of Bristol, Southampton and Sheffield.

The work on pile foundations is a joint effort between the Institution, the Federation of Civil Engineering Contractors and the Building Research Station. One aspect of this work is the improvement of pile loading tests; an investigation on model piles in sand is also being undertaken at the University of Belfast. The work of the fatigue committee is still only in the preliminary stages. A programme of research has been drawn up and priorities settled. One difficulty, however, is finding suitable test equipment large enought to handle civil engineering components, few, if any of the universities, having such equipment.

At the universities research work covers a very wide field. Nearly every civil engineering department is tackling a structural problem, such as the load capacity of steel or light alloy frames or the strength of concrete members, either reinforced or prestressed. Hydraulics, though not so popular as structures, is another sector in which a great deal of work is being done. At Southampton they are particularly fortunate in having the big Caltex model which accurately represents the double tides experienced in Southampton Water. Soil mechanics, on the other hand, still provides many of the universities with topics for research.

The principal DSIR establishments concerned with civil engineering research are the Building Research Station at Garston, the Road Research Laboratory at Harmondsworth (with its twin divisions, the one dealing with traffic and the other with materials and methods of construction) and the Hydraulics Research Station at Wallingford. Perhaps the biggest problem facing Government establishents was stated by the Building Research Board in their last annual report: they said that the Station should "approach the question of recovering money from industry with a greater determination."

Much of the work of the Hydraulics Station is concerned with the construction and operation of loose bed models of particular harbours and rivers where new works are being planned, to which reference is made under Design. One research topic that is receiving great attention is coast erosion. For this work the Station has built and is operating their "basic coastal model." The relationship between rainfall and river flow has also been the subject of study.

At the Building Research Station, research has centred on building techniques: the new lightweight brick owes much to the work of the Station, and a lot has been done to develop the economic use of site machinery, particularly the tower crane for handling materials. The contribution made by infillings to the strength of building frames is being examined analytically and experimentally with the object of reducing the size of the members required. Considerable work is also being done to improve the "efficiency" of buildings in respect of heating and insulation.

At the Road Research Laboratory a particular problem under investigation is that of equating the soil foundation, the traffic to be carried, and the thickness of the pavement to be installed on new roads. On the construction side, work is continuing on developing better techniques for compacting road foundations and also on producing non-skid surfaces. On the traffic side, emphasis is being placed on determining the economic vehicle capacity of roads. Data being compiled by the Laboratory are helping to establish when an existing road should be enlarged and, by predicting the possible savings, establishing priorities for differing projects.

Perhaps one of the healthiest signs in the industry is the continued growth of contractors' laboratories. A few years ago only a handful of the contractors maintained laboratories and their work was usually restricted to small soil mechanics and concrete testing rooms which were primarily concerned with checking specimens and samples from individual contracts.

Now, however, a number of contractors have developed large laboratories, employing in some cases 200 to 300 staff and working on a far wider range of topics, including mechanical and electrical topics. New materials are being sought, especially lightweight concretes and cement substitutes Efforts are also being made to improve durability of buildings materials. Construction techniques are being examined, with a very special emphasis on ground engineering. And, on the basis of their laboratories, many of the contracting companies have built consultant services that undertake primary site and survey investigations.

Design

Models are playing a very important part in design these days. Hydraulic models of major harbours and the larger rivers have been in use for some years but recently the techniques have been applied at the Hydraulics Research Station with advantage to small fishing harbours and to investigating flood prevention schemes of quite small streams. Tests are also regularly carried out on the spillways of dams and the water intakes of reservoirs.

For structures, considerable use has been made for many years of two-dimension outline Perspex "models" of frames, but recently a much more complicated technique, using scale models, has been developed for tackling problems where the analytical conditions are intractable. Thin arch dams of the cupola type require such treatment, and bridge and industrial structures have also benefitted from such an approach, especially where conoid roofs are involved.

Computer techniques are also gaining popularity and a number of programmes have been set up for structural frames. The Cement and Concrete Association have established a library holding computer programmes relevant to all civil engineering topics. A number of problems have also been tackled on the computer at Southampton University where a strong department of civil engineering is well able to assist with the analysis of a problem. The structural division of the United Steel Companies are using a computer to tackle floor grids and are extending the approach to columns.

Models are also being successfully used to plan projects; in this respect the process industries, especially the oil refineries, have given the lead. Drawing board work on layouts is eliminated, the project layout being designed as the model is built, though a conventional approach is still required in the design of structural framing and the reactor vessels themselves. Plans do not have to be drawn from the model for record purposes or for contractors and sub-contractors: the model is sufficient for the project to be priced and built, and can be used for instructing erection gangs and operating staffs. Complete refineries have been designed and built this way and it would seem that the method can be used with advantage for projects outside the oil and chemical process industries.

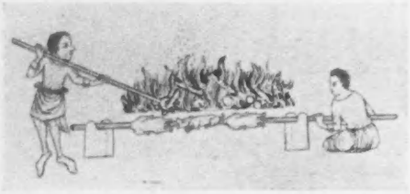
Acceptable stresses are still rising for concrete and the attainable load in prestressing tendons has now reached at least 108 tons per cable, making possible very large prefabricated beams for bridges and framed buildings. The steel industry, in an effort to combat competition from concrete in the buildings field, are doing much to encourage the use of lightweight fire-resistant protection, such as vermiculite and gypsum plasters. Efforts are also being made to interest architects in the use of steel in the hope of getting a better aesthetic treatment, such as concrete and structural timber enjoy. Some bridge designs entered for the United States Steel Company's highway bridge competition incorporate some pleasing lines.

Over and above structural form and the calculation of stability, the designer is faced with minimising future maintenance costs and, in buildings, providing maximum fire resistance. On maintenance alone steel and timber lose out to concrete and aluminium alloys for the first two require painting—though the new vinyl coatings will cut the frequency of repainting required. In fire resistance, too many structural engineers and architects are woefully ignorant of the facts. More attention to such details is bound to follow the appalling losses by fire that there have been during the last three years.

Roast for Dinner (Mechanised)

Do you live to eat or eat to live? Throughout history adherents of both precepts have existed side by side. During the middle ages and up to comparatively recent times "a good trencherman" was one to be respected. In gross epochs when other amusements were few, the pleasures of the table were one of the highlights. More recently the cook's problem was to tickle the jaded palate.

Roasting ("broiling" to Americans, but the two are different in England) is one of the older Methods. It must have been realised quite early that to get an even roast the joint must be turned so that all parts are exposed to the fire. The illustration from the *Lutterell Psalter* (one of the mines of information on English life in



The Lutterell Psalter shows how roasting was done in the 14th Century.

the 14th Century) shows the roast in progress. It must have been a tedious job and there is not even a crank to help turn the spit.

The second illustration, of an Italian kitchen about 1550, shows rather more mechanical development. At least the spits have a cranked handle and a "forced" draught is supplied by the gentleman with the bellows. Economic use is made of the fire to cook the whole dinner.

But man is incurably lazy and mechanisation was not long in reaching the roasting spit. Clocks, weight driven, were becoming generally used and the principle was quickly applied to the spit. A gearbox stood on the mantleshelf, consisting of a drum on which the weight cord was wound, a pulley with a rope drive to the spit, and some sort of gearing to drive an air friction governor. A wheel and worm were

The modern Rotisserie unit also cooks the whole dinner but requires a very small space and no help from scullions.

frequently used for this drive as they gave a high speed increase.

Other mechanical ideas included what must have been one of the first hot air turbines. An illustration of 1656 shows the machine. In the flue of the chimney is fitted a broad bladed fan that is turned by the ascending smoke and air. This drives through vertical shafting to reduction gears and then to a lantern wheel driving a crown wheel on the end of the spit. In keeping with the times, the illustration shows the other end of the spit being held by a female statue, rather scantily clad.

However, all these methods required a large open fire and when the smaller range came in they could not be used. Roasts were therefore done in the oven (and ceased to be technically "roasts") and presented additional problems in basting and turning. Until the last twenty years or so these were the only possibilities.

Investigations into the infra red-range of the spectrum showed that waves of this length could heat solid objects on which they impinged. Moreover, they heated the inside of objects as well as the outside so that a much more even effect was obtained. The idea was first applied to space heating and then to the more intense and directional needs of cooking. It was found that the time required for roasting was greatly reduced and that compact units could be made to run from the ordinary electricity mains. With domestic service at a premium, the future seemed assured.

One of the most recent examples of the modern

An Italian kitchen of 1550 had a central cooking fire for the whole dinner.

spit is the Kenwood Rotisserie shown in the third illustration. Like the Italian charcoal fire, it is cooking the whole dinner, but the absence of scullions is noticeable. Admittedly, the amount of food is somewhat less, but again this is typical of the times. The Rotisserie would not look out of place on the dining room table.

Operation is electric and automatic. The spit rotates slowly under the infra-red element which has three grades of heat. When the food has been placed in the chamber the required time and heat are set and the cooking started by switching on. Switching off is automatic at the preset time. When desired a gridiron can be fitted on the spit for roasting small cuts, steaks, sausages and fish. There is a four level grill stretching the full width of the plate for savouries, fish dishes and quick toasts. A hook-on handle makes for easy handling. The hot plate above will fry bacon in the two serving dishes, heat the coffee or keep vegetables warm.

The Rotisserie measures 21 in wide with the spit handle extending another $5\frac{3}{4}$ in; 11 in deep and $13\frac{1}{4}$ in high. The weight empty is 21 lb. The three heating ranges are: low 250 watts, medium 690 watts, and high 1,120 watts. The corresponding temperatures at the spit are 210° F, 400° F, and 550° F. These are with the glass door closed. Voltage ranges for which the unit is available are 200/220, 230/250, and 110V, alternating current only.

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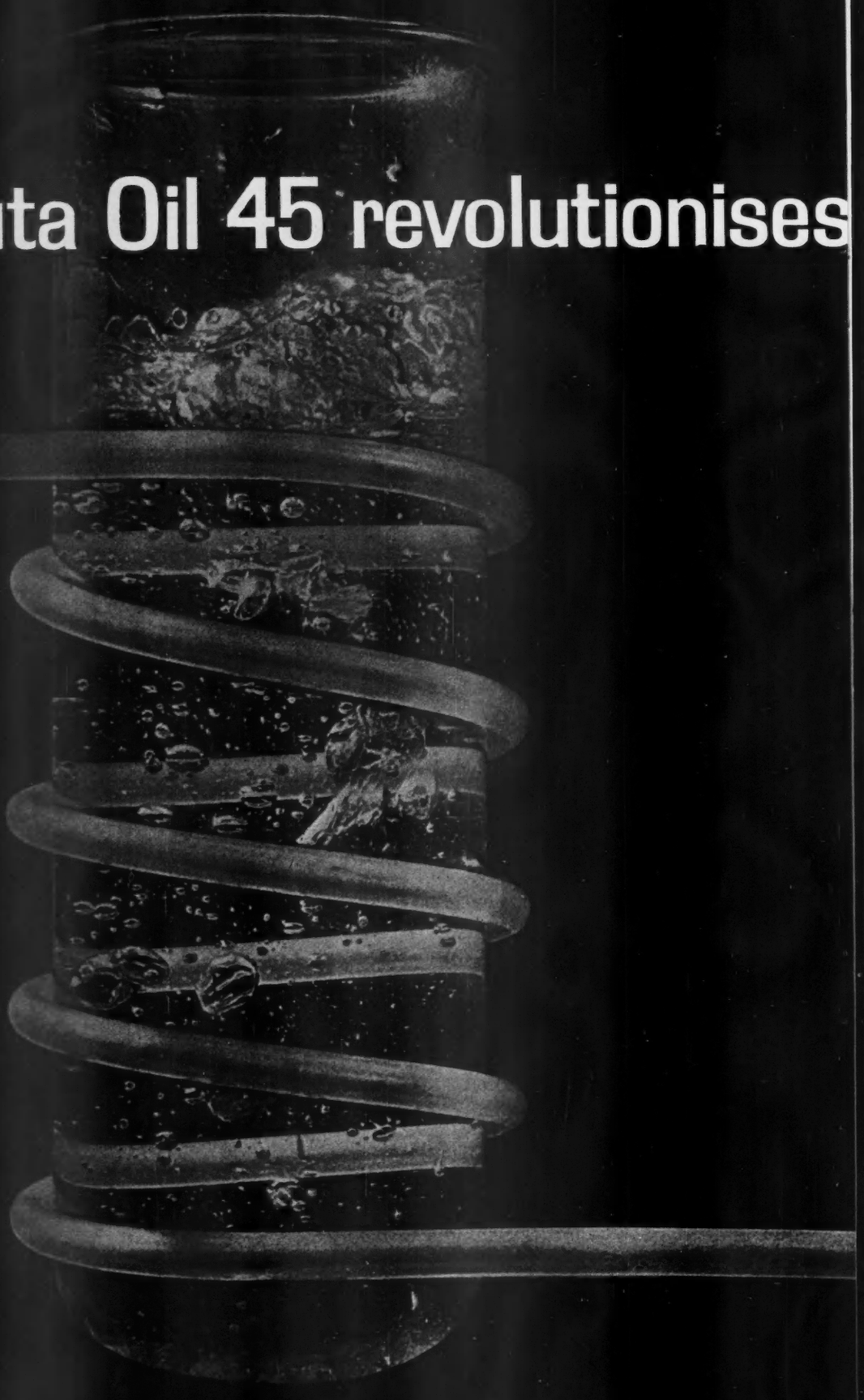

heat exchange practice

Before Shell produced Voluta Oil 45 it was thought that oils which were to be used for heat exchange purposes must have a high flashpoint—to reduce fire risk—and a high viscosity to prevent excessive leakage through pump glands and to provide adequate lubrication for pump bearings at high temperatures. Heat exchange systems containing these viscous oils, however, were sluggish, particularly when started up from cold. The oil circulated slowly over the source of heat and suffered thermal decomposition, or "cracking". This, in turn, produced low flashpoint materials and carbon which insulated the heating surface.

Shell, therefore, began investigating the suitability of oils of lower viscosity and different chemical constitution. From this research was developed Shell Voluta 45.

Shell Voluta 45 contains hydro-carbons with a saturated ring structure which does not have the tendency that high viscosity straight chain paraffin hydrocarbons had—to break down at high temperatures. Because of its low viscosity Shell Voluta 45 heats up more quickly from cold and circulates more rapidly thus avoiding local overheating and thermal decomposition.

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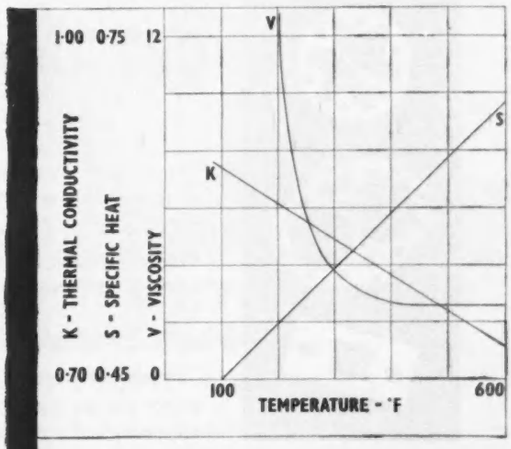
Laboratory research to compare the high temperature performance of various oils in a rig simulating practical conditions showed that when oils of varying viscosities were maintained at an average temperature of 325°C. for 200 hours, the closed flashpoint of the high viscosity oils had dropped to a lower figure than that of oils of lower viscosity, indicating that some thermal decomposition had taken place.

Experimental oils were subjected to Heat Stability Tests and to tests designed to measure the variation in heat transfer coefficient with time. The most promising of these oils was then given extensive field trials, both in Shell Installations and in industry. From this extensive research was developed Shell Voluta 45.



Physical properties of Shell Voluta Oil 45.
K. Thermal Conductivity—B.T.U./sq. ft. per hour per 1°F. per inch.
S. Specific Heat—B.T.U. per lb. per 1°F.
V. Viscosity—Kinematic centistokes.

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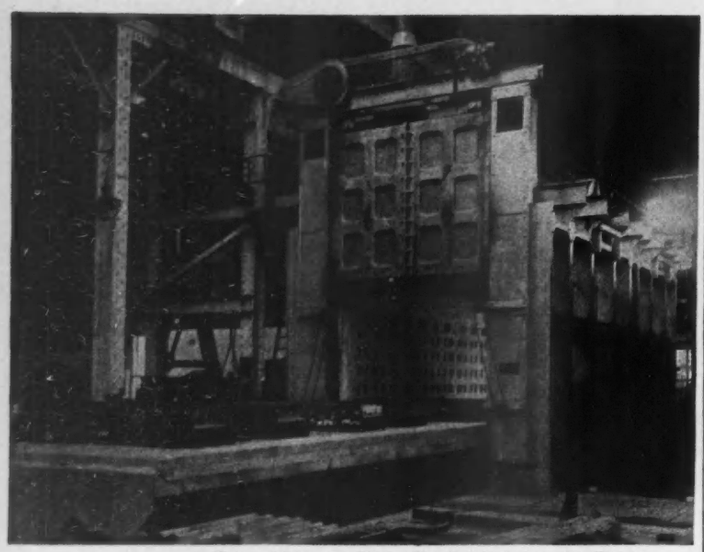

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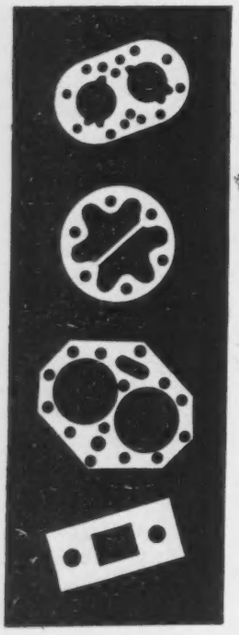

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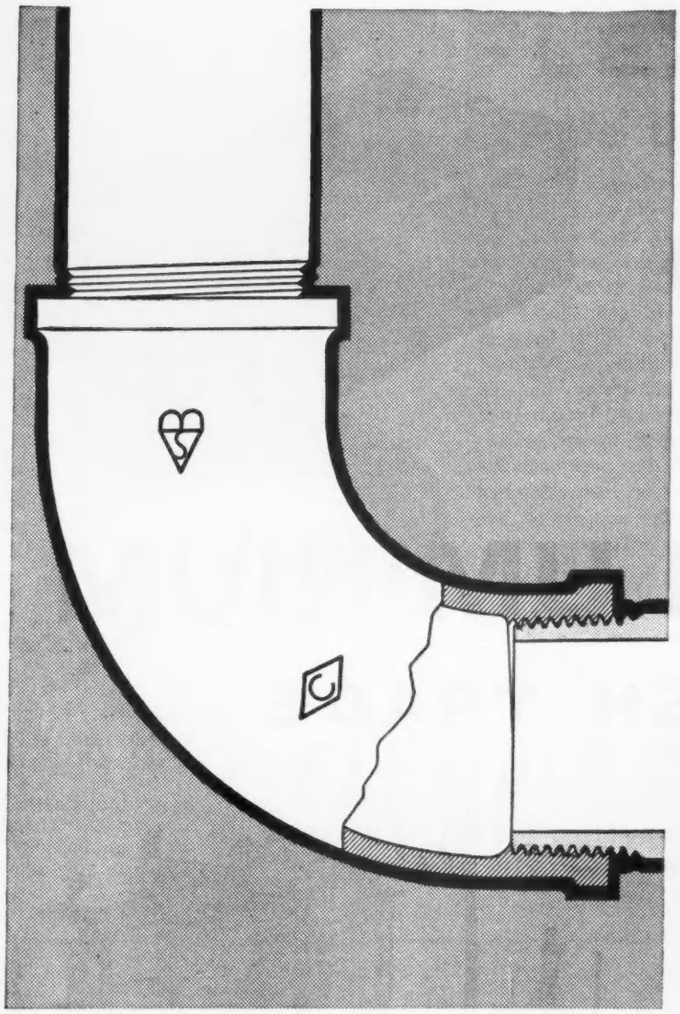

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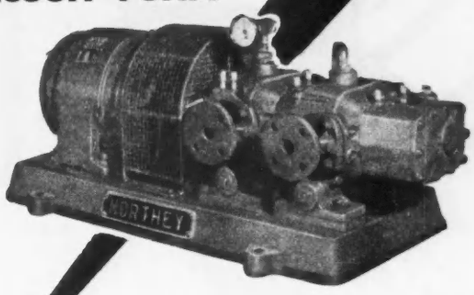

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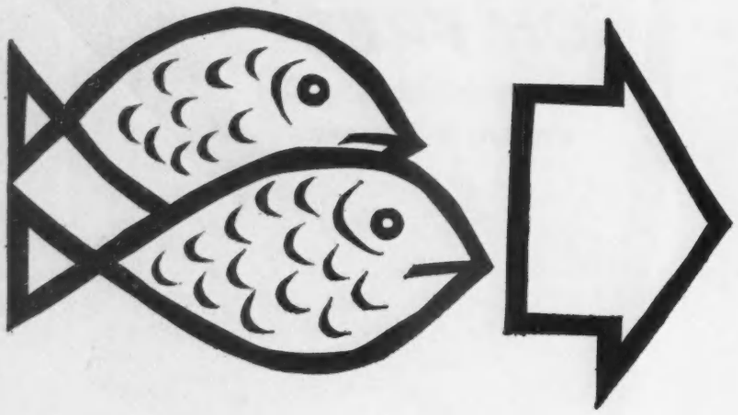

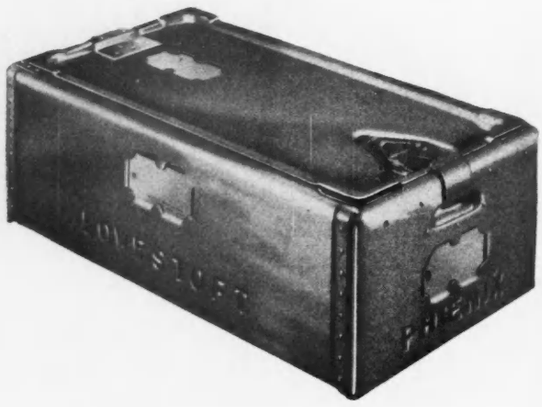

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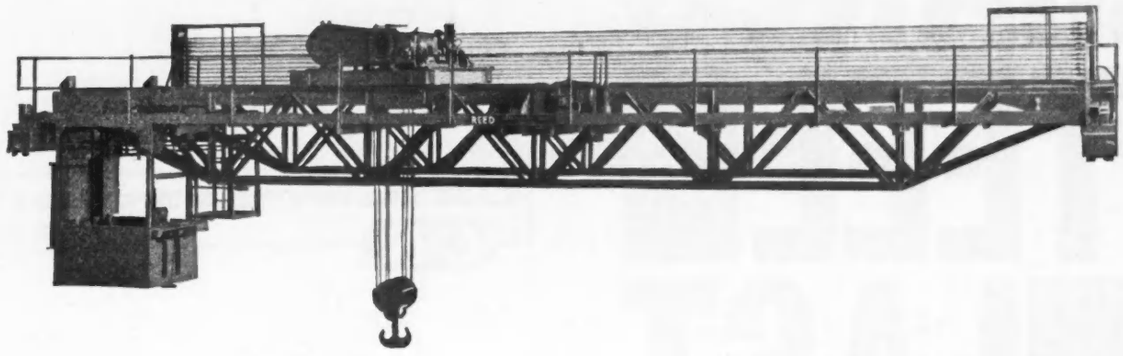

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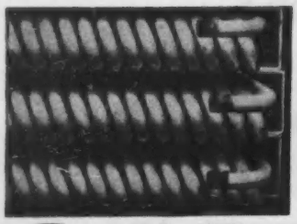

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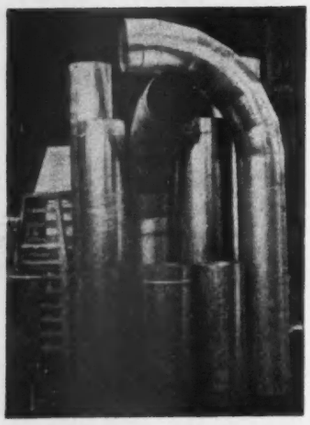

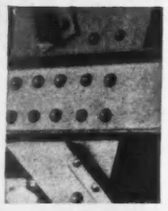

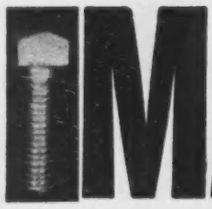

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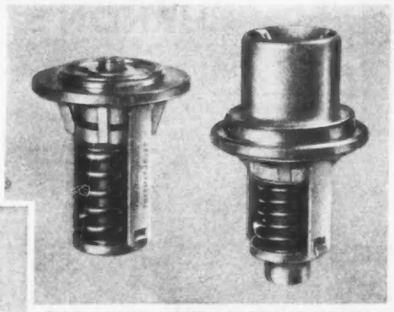

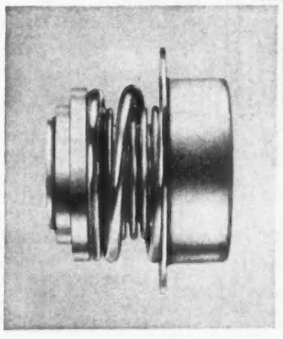

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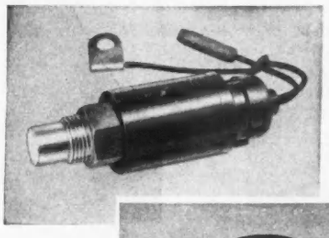
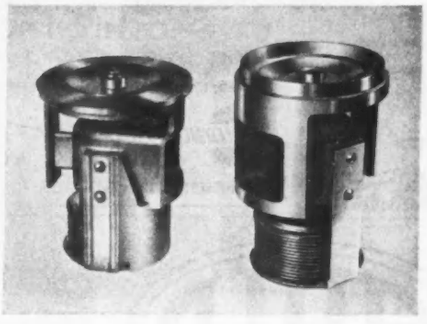
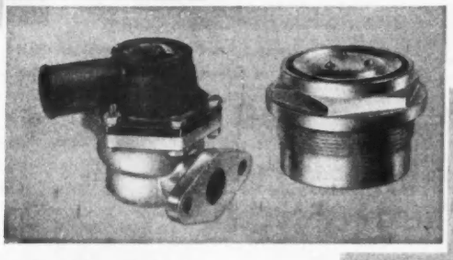
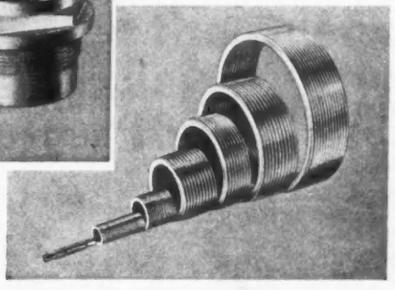




ENGINE COOLANT THERMOSTATS



PRESSURE RELIEF VALVES



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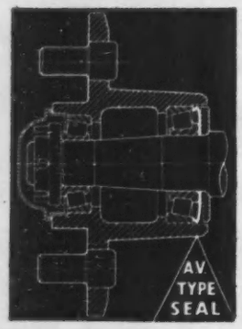

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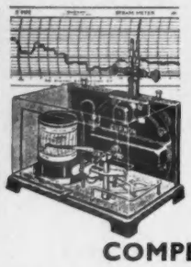

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- High efficiency
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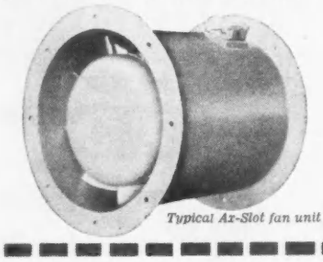
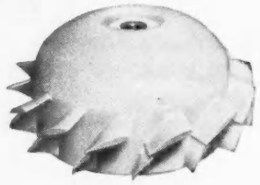
The Ax-Slot fan marks a major advance in axial fan design. The slotted blade formation gives 'boundary layer control' extending laminar flow over a large portion of the blade chord and, at the same time, permitting the use of greater flow deflection angles. This offers the engineer the choice of designing for higher efficiency or higher pressure ratios, or a combination of both. Higher pressure ratios and minimum losses due to turbulence and blade friction result in designs where size, weight, noise and vibration are all reduced.

These qualities make the Ax-Slot particularly suitable for many industrial, general marine and aeronautical applications. This patented design of fan is, in fact, in service in all the American nuclear-powered submarines.



Typical Ax-Slot fan unit



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* *Ax-Slot is the trade name of axial fans with slotted blade formation which are to be manufactured in Great Britain by Keith Blackman Ltd. in agreement with the General Dynamics Corporation, Electric Boat Division, Connecticut, U.S.A.* TA3121/1034

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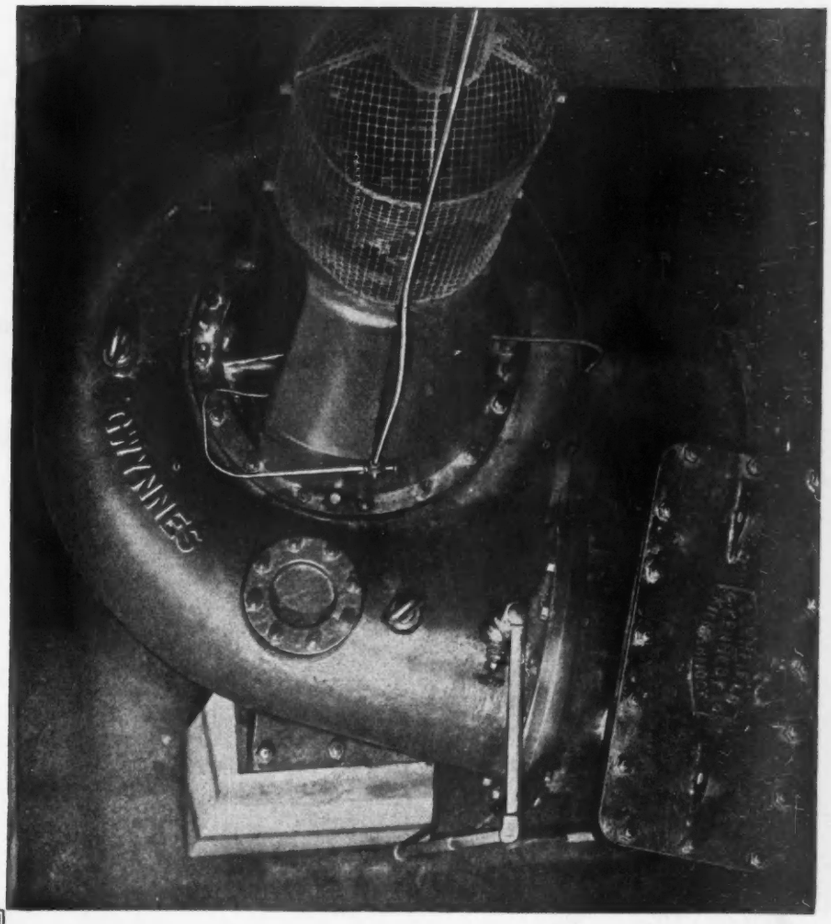

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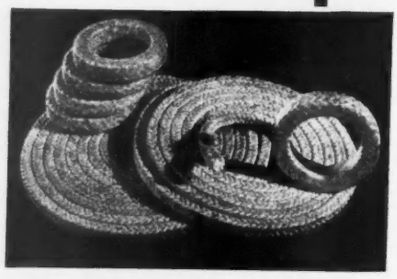

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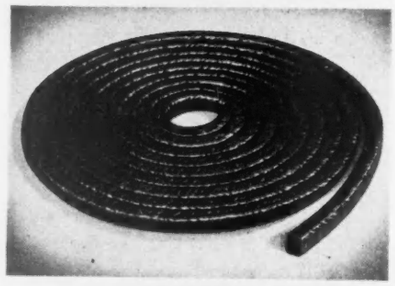

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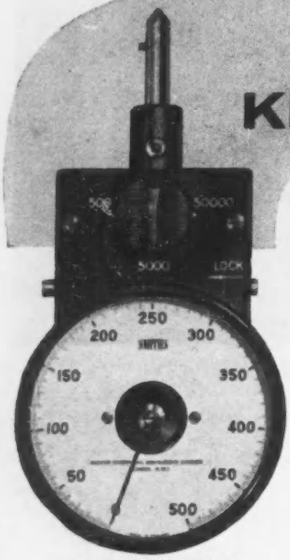

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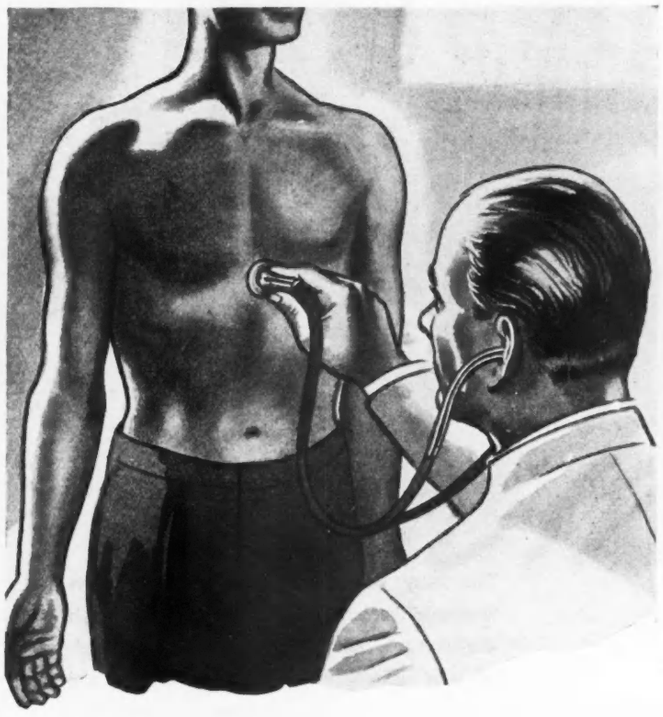

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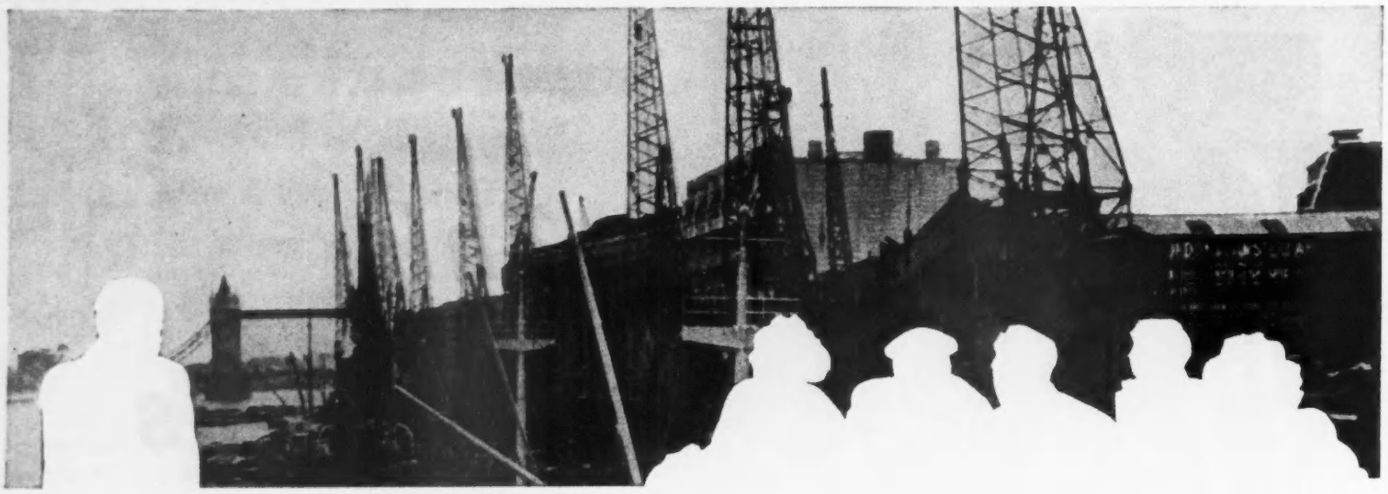

watching the cranes go high

The busy scene at the dockside has always fascinated that large part of the human race which just likes to stand and stare. These cranes loading and unloading at the Port of London and their appreciative audience form a picture which is repeated with variations at docksides all over the world.

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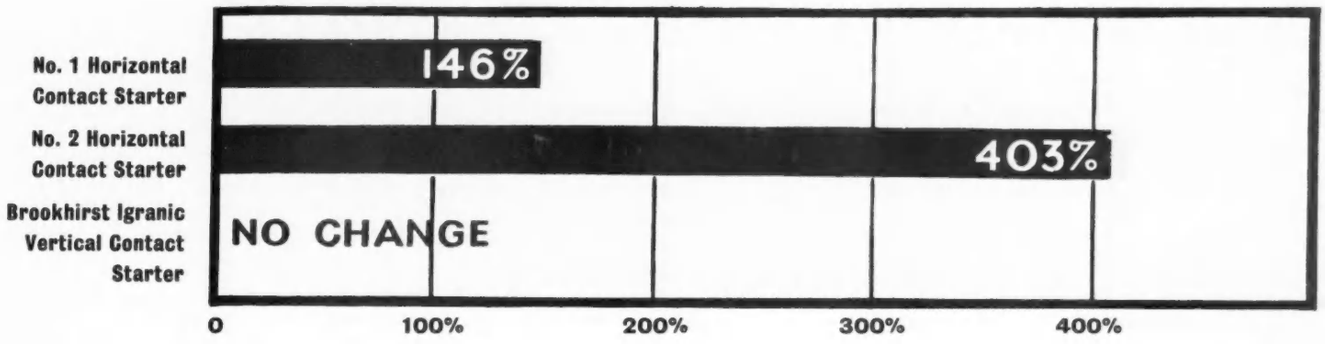

A Brookhirst Igranic motor starter with vertical contacts was tested in a standard dust chamber along with two starters with horizontal contacts.

The Brookhirst Igranic vertical contact starter alone showed no increase in contact resistance due to dust deposits, because dust cannot collect on vertical surfaces. Increased contact resistance through dust leads to heating, pitting, wear and failure.

Vertical DUST-SAFE contacts are Brookhirst Igranic standard.

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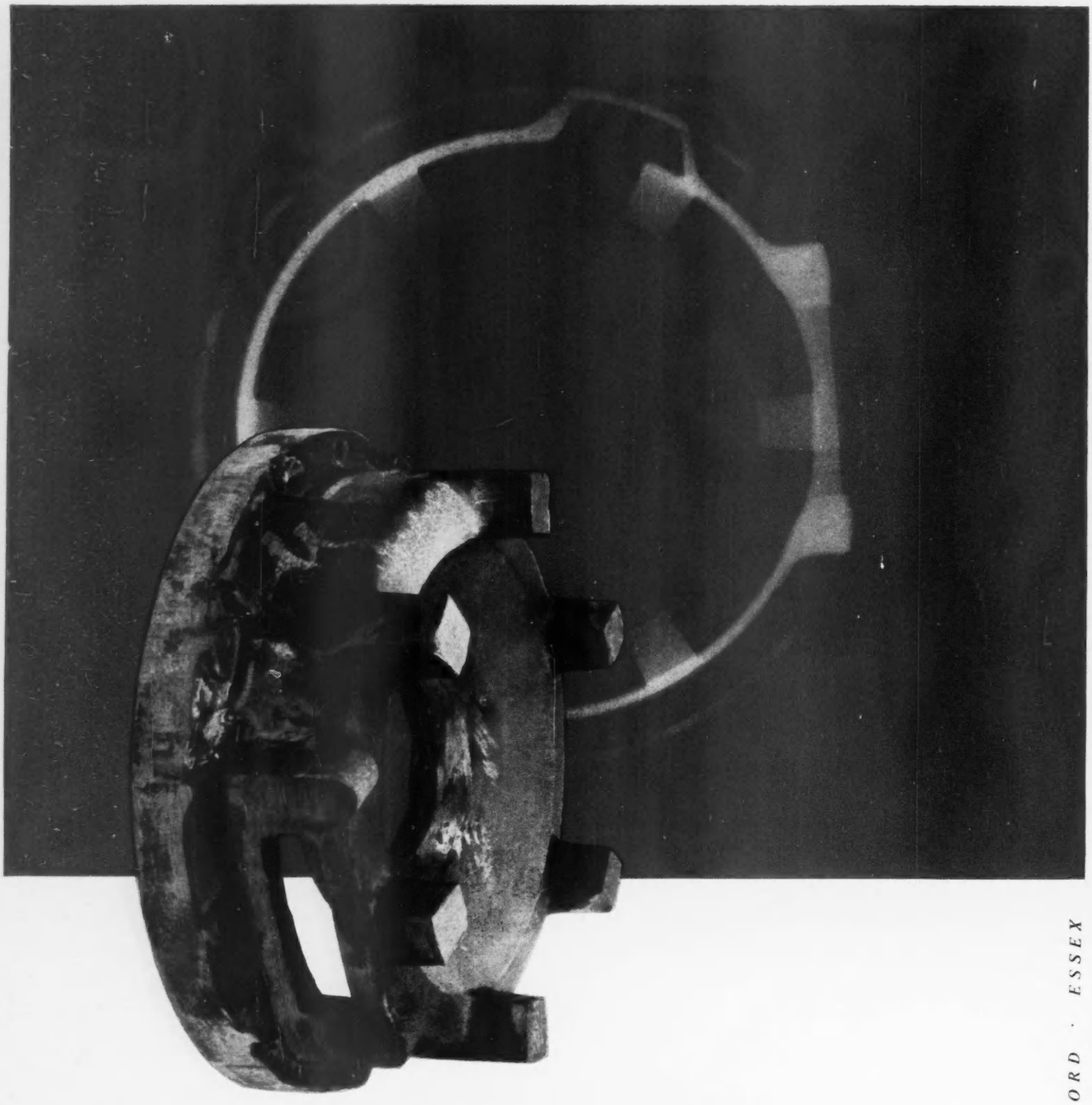

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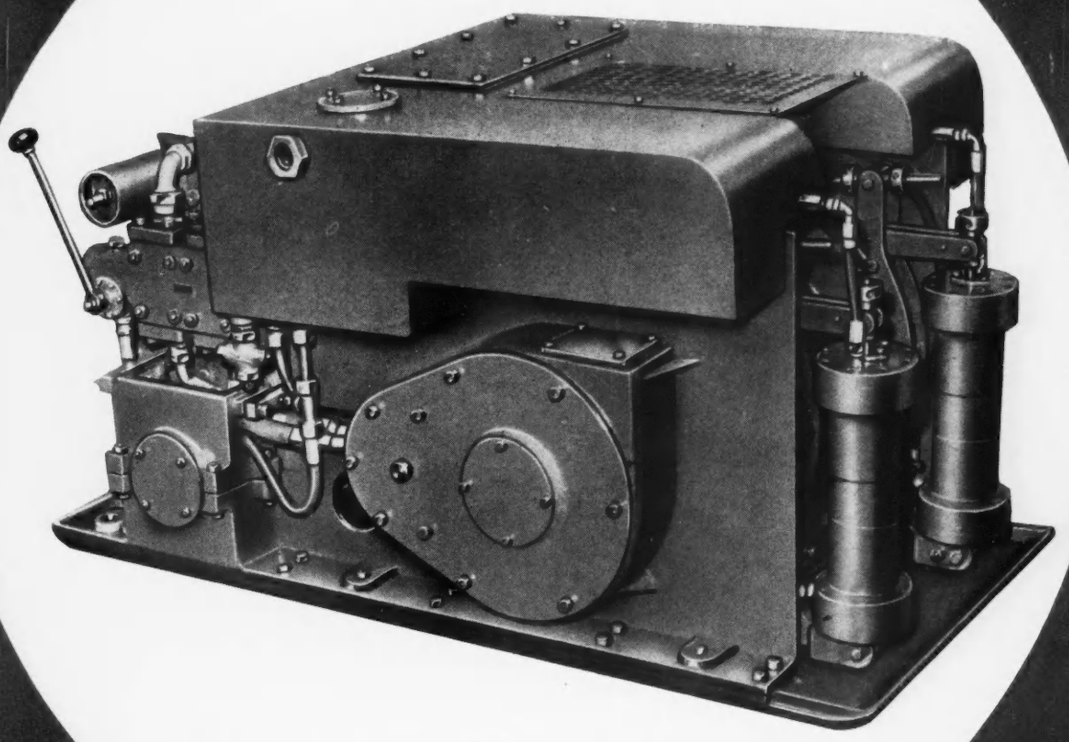

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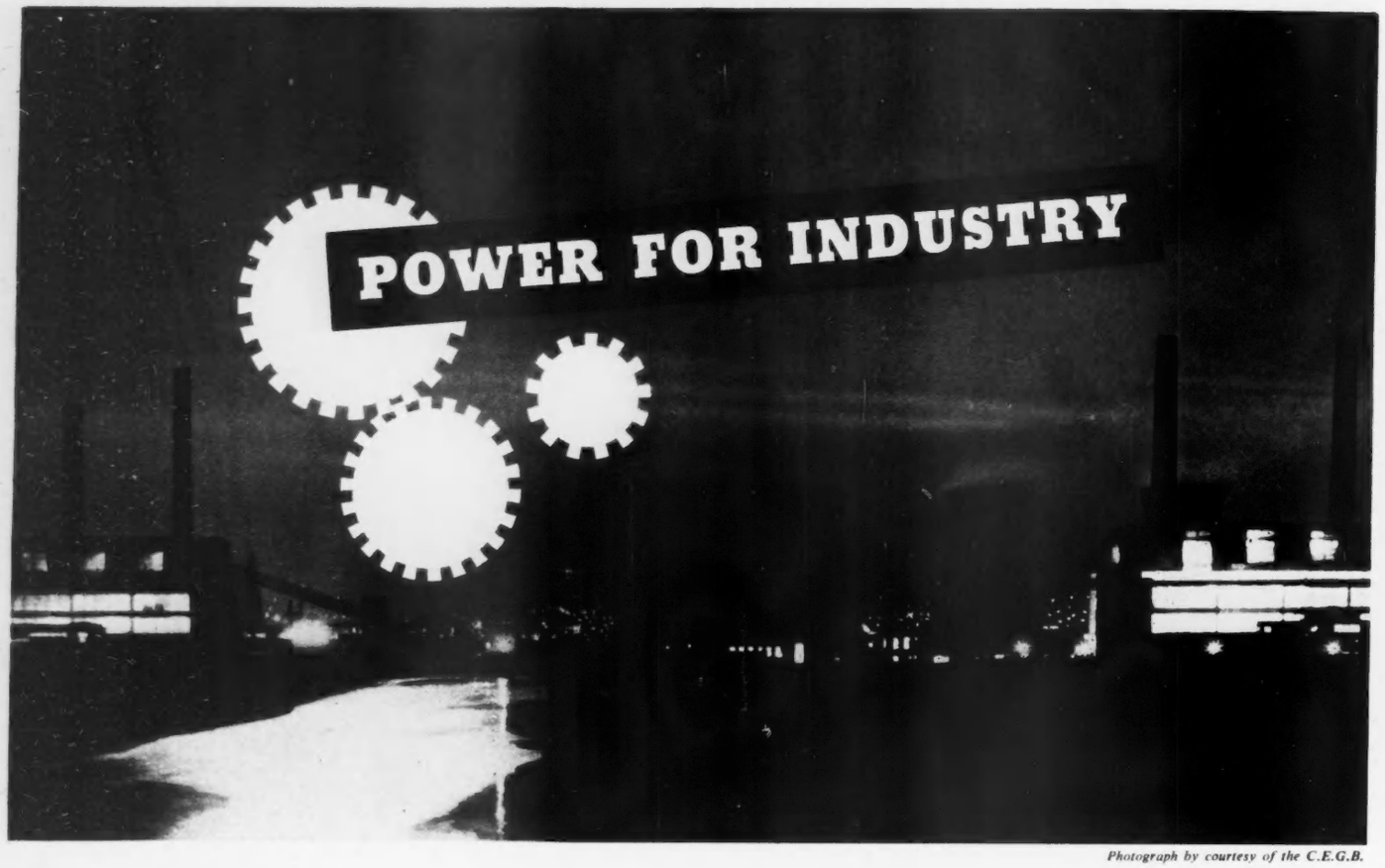

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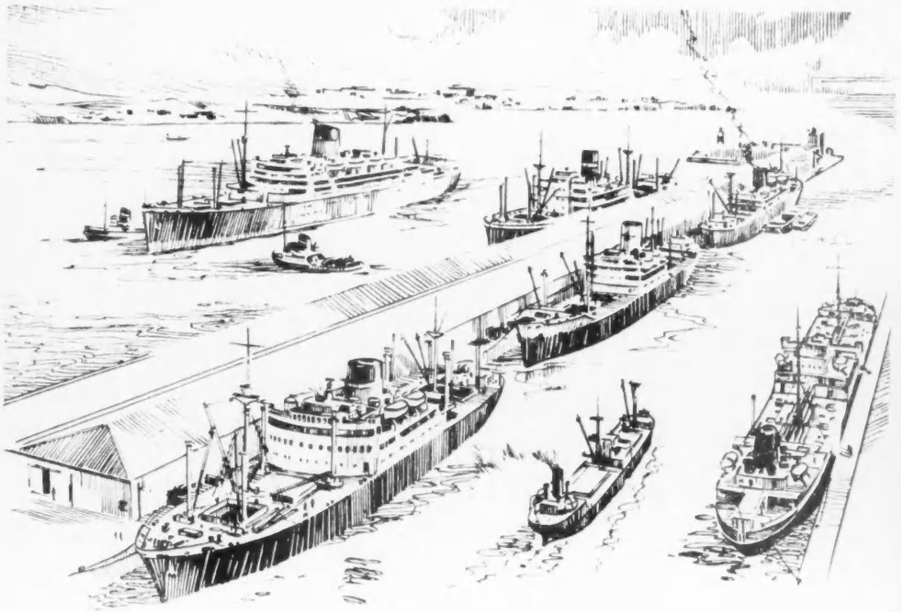

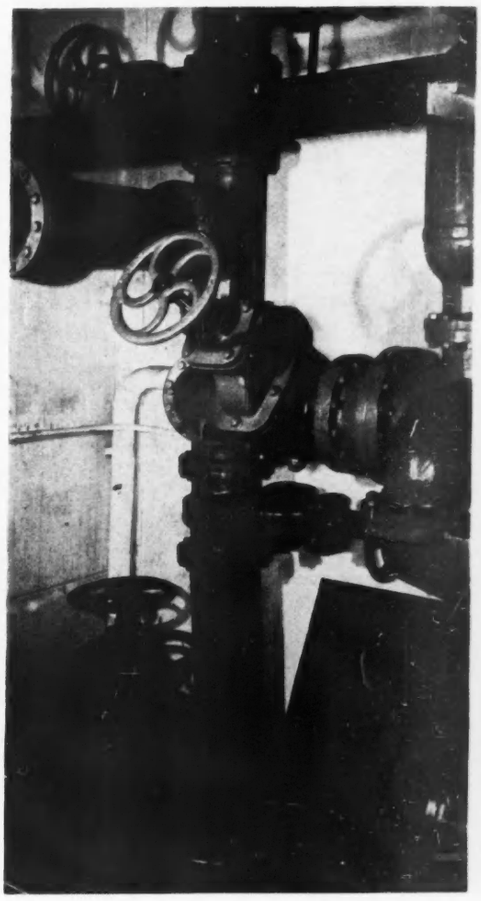

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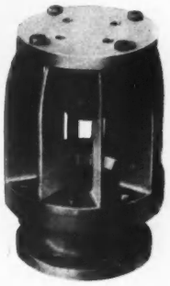

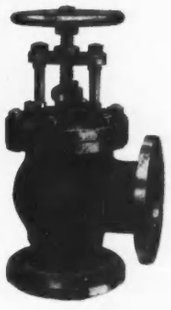

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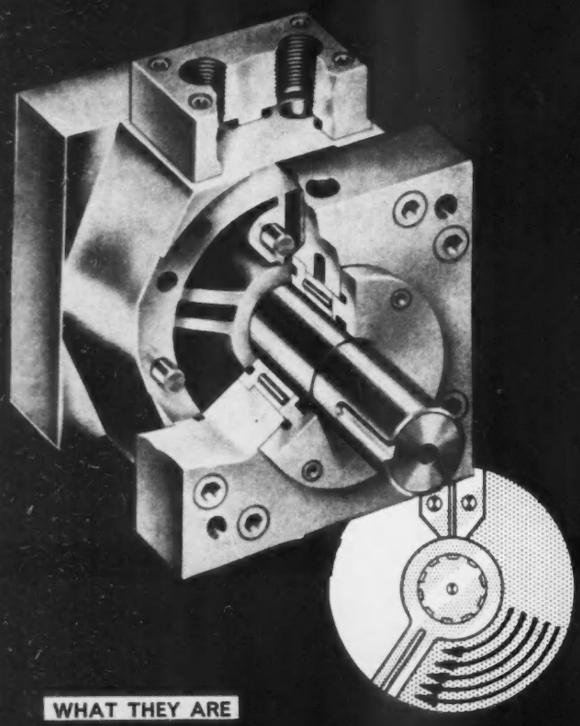
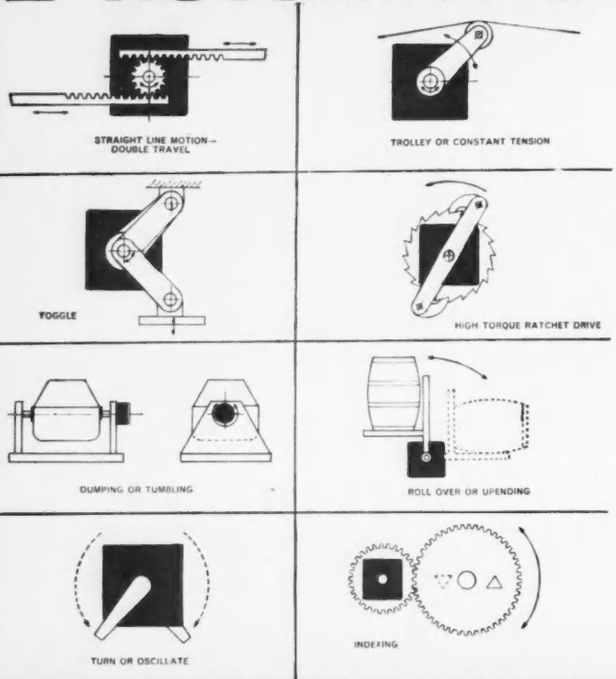


WHAT THEY ARE

WHY THEY ARE BETTER



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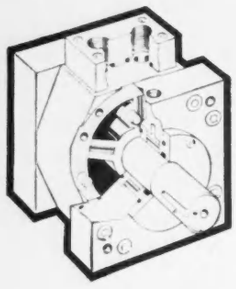

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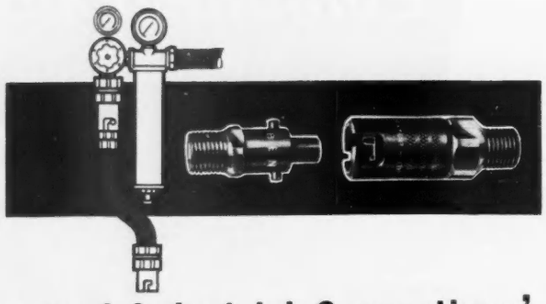

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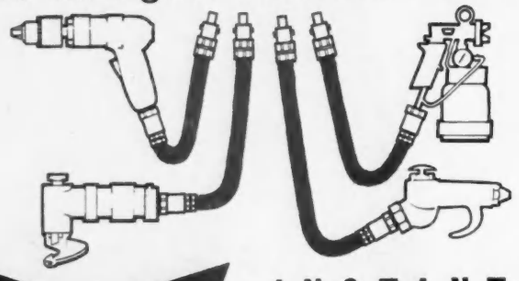

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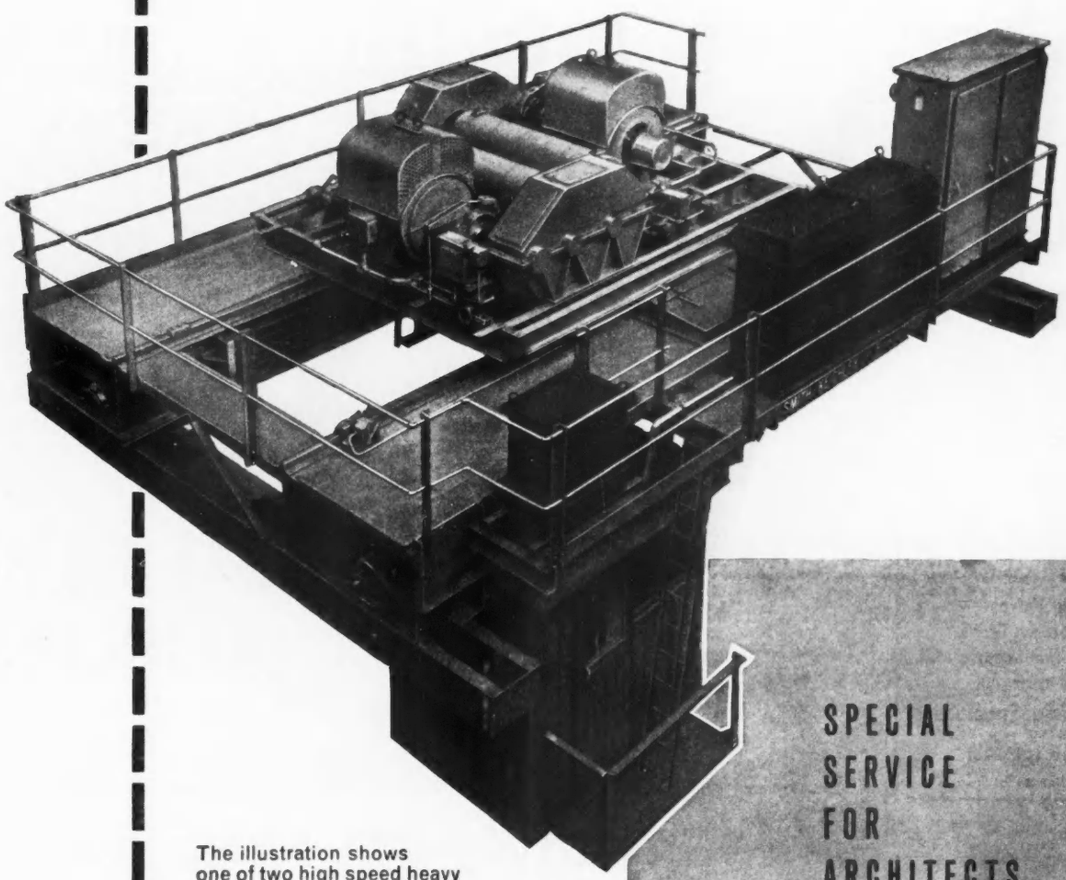

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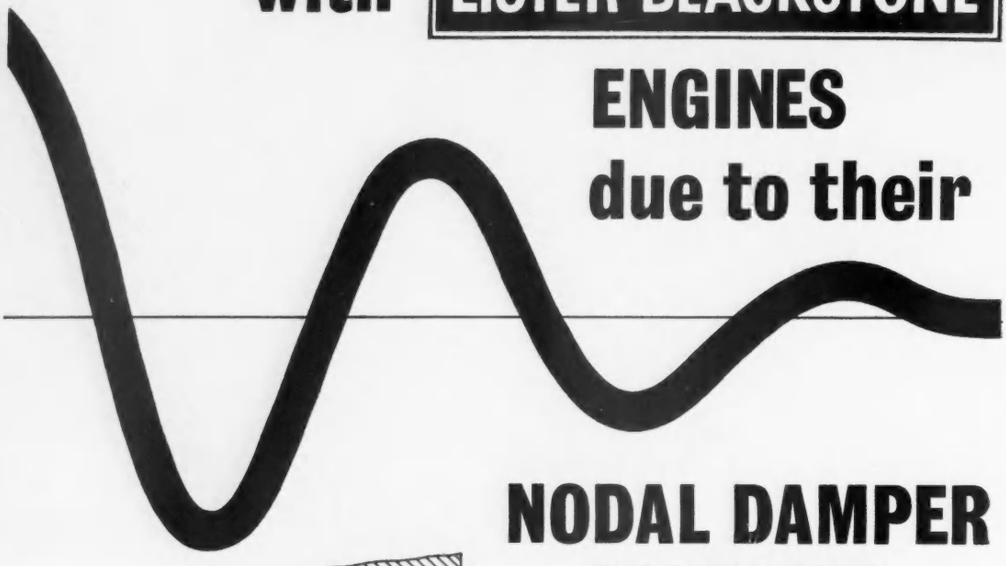

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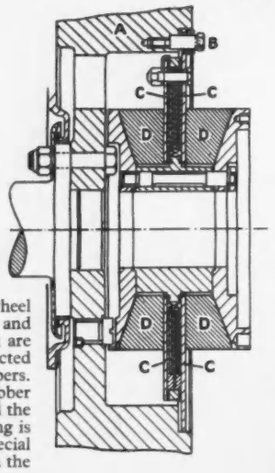

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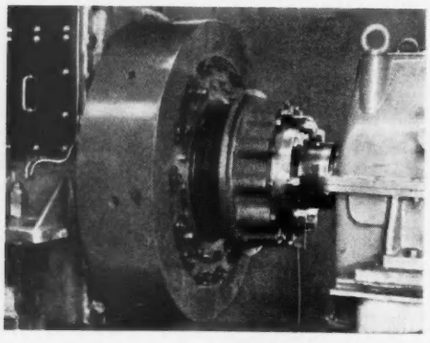

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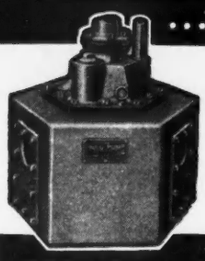

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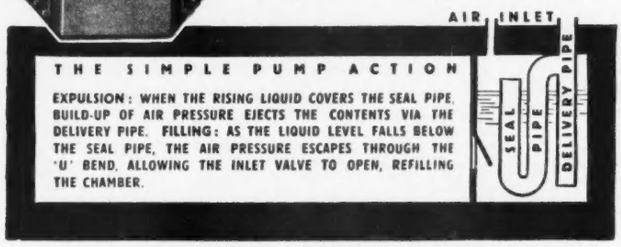

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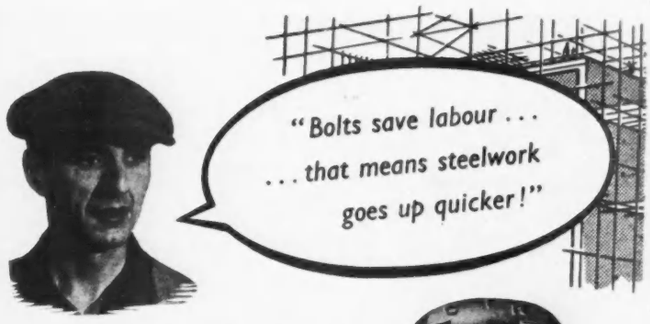

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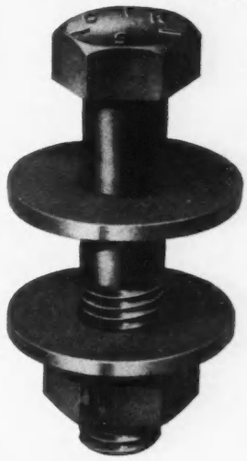

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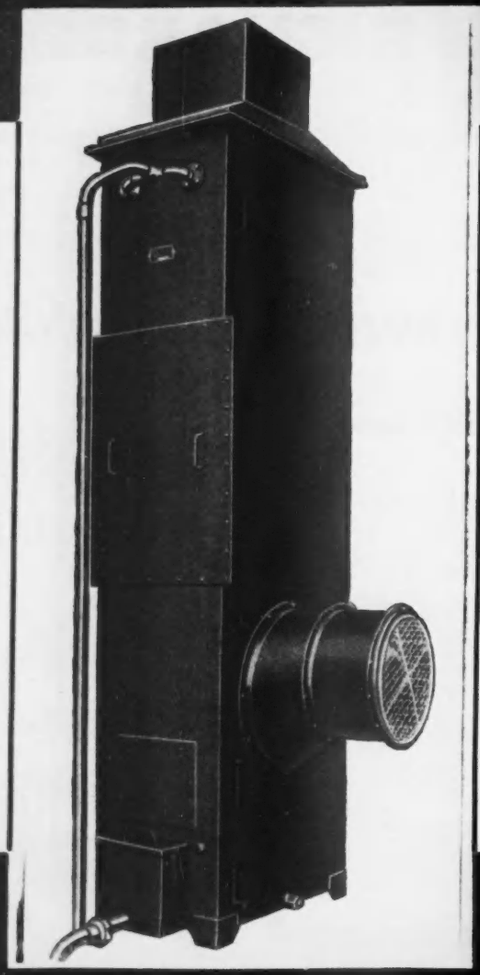

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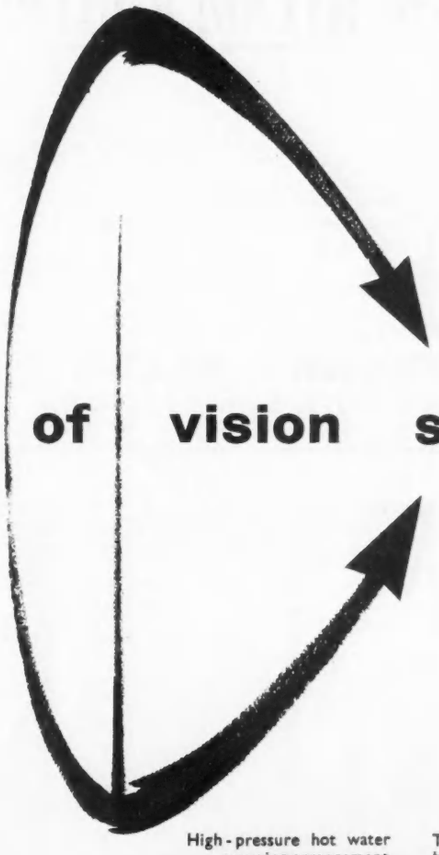

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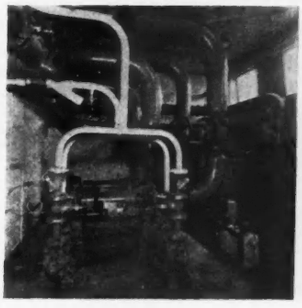

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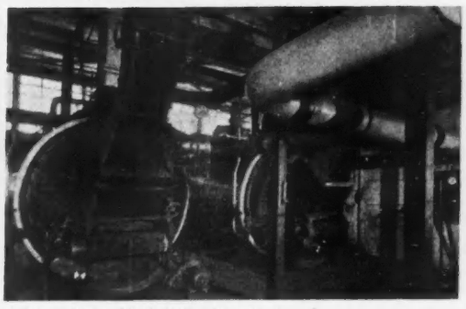

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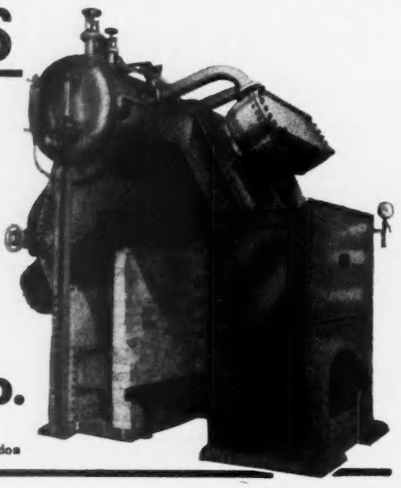

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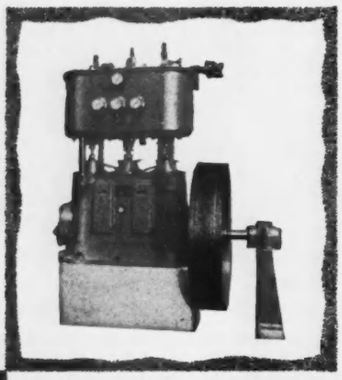

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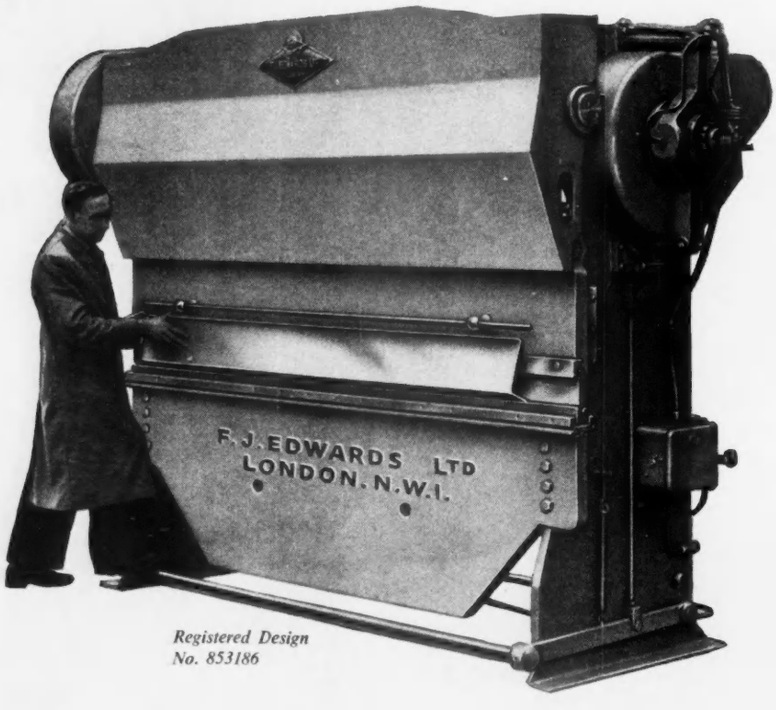

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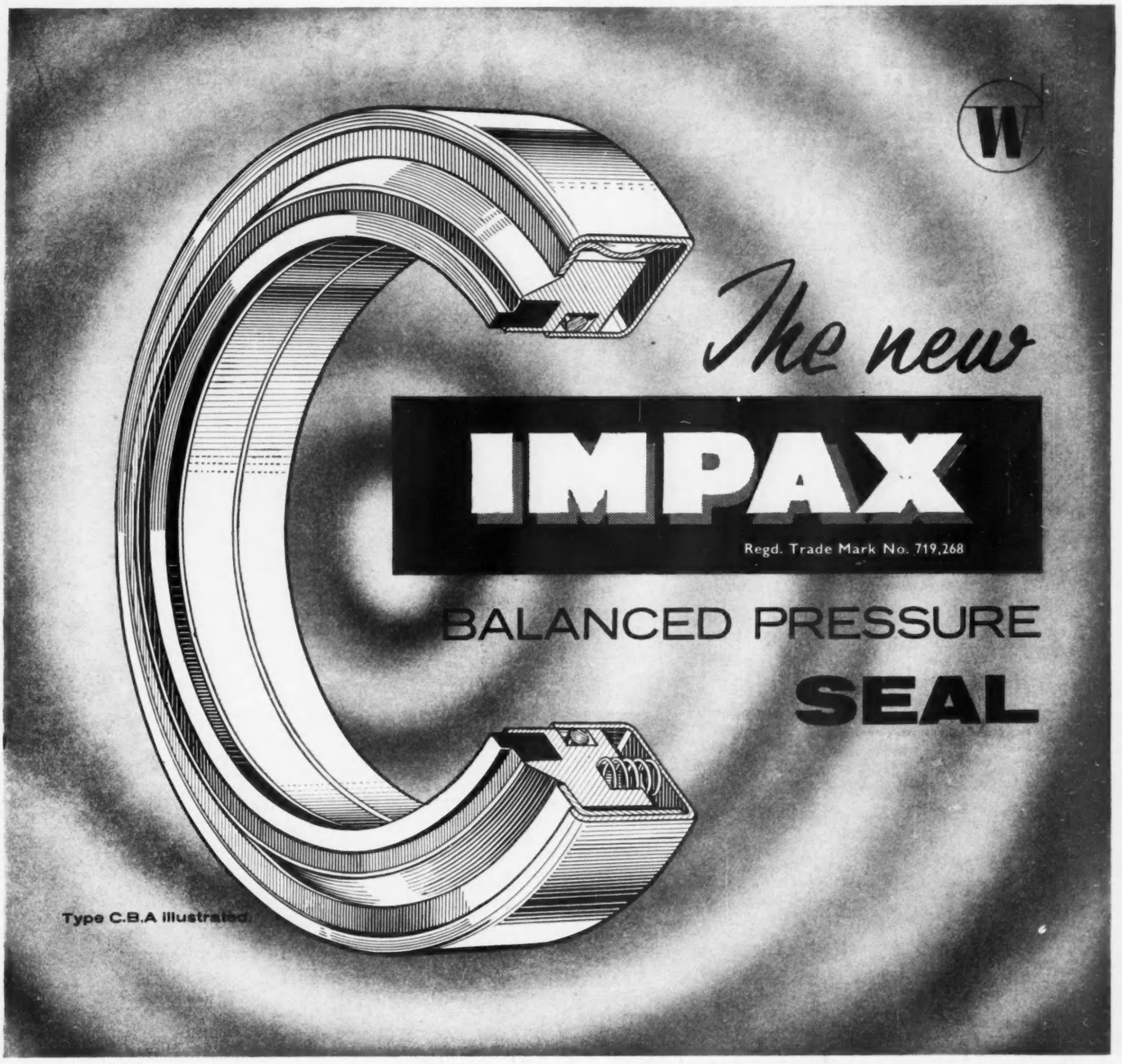

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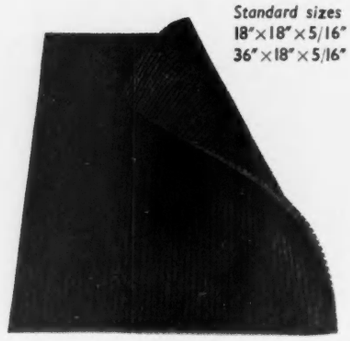

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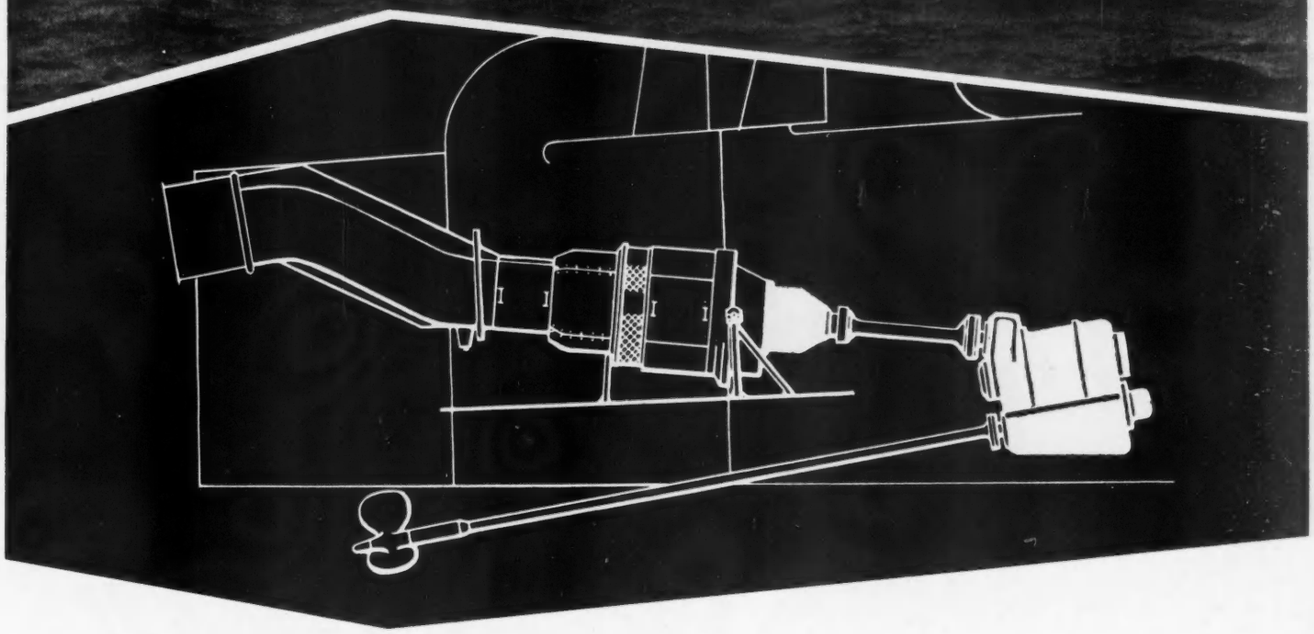

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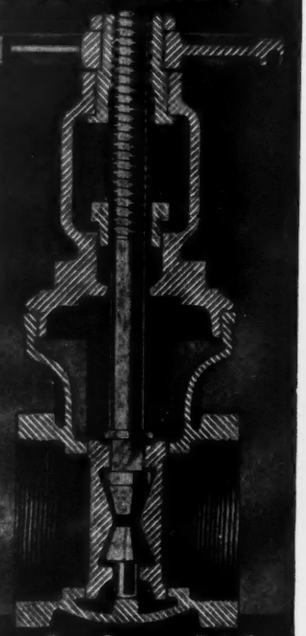

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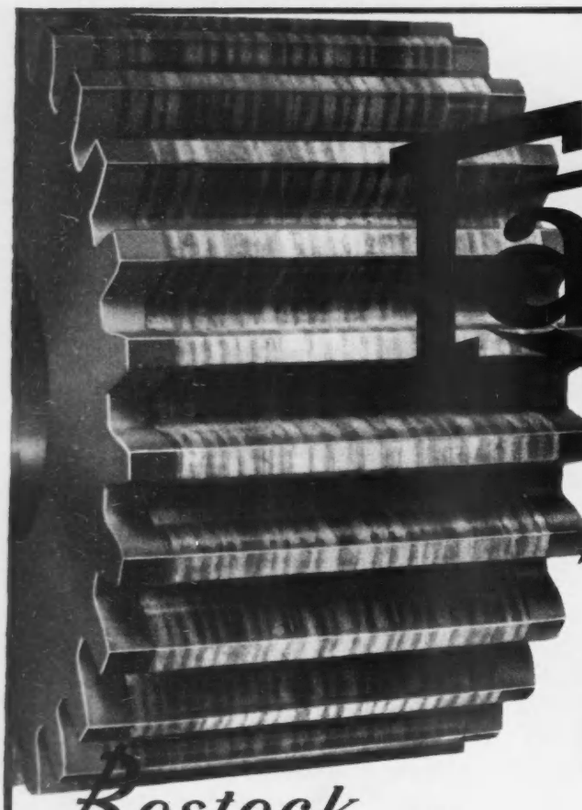

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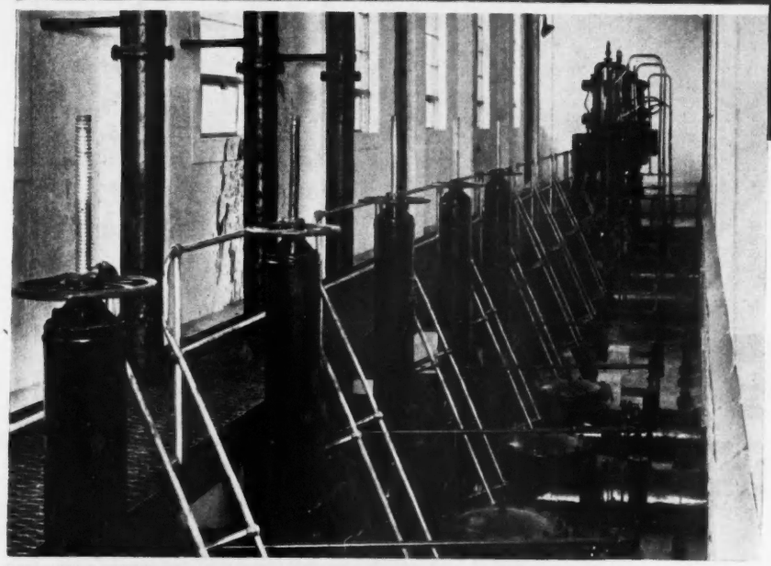

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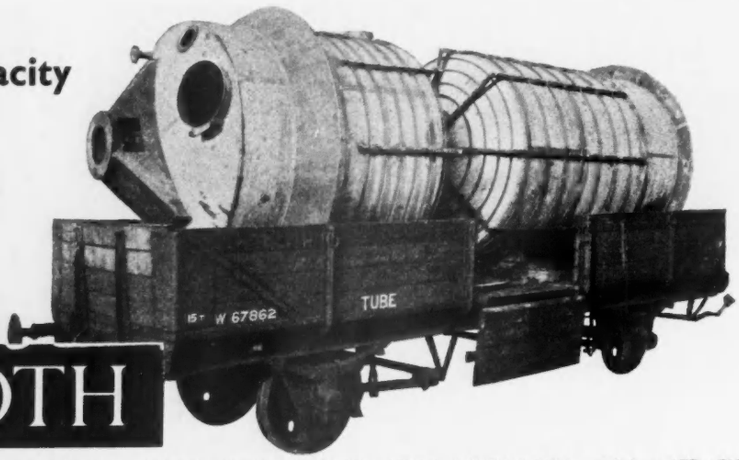

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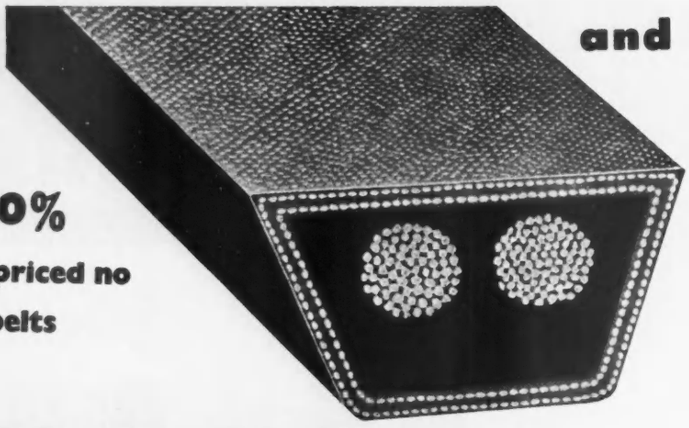

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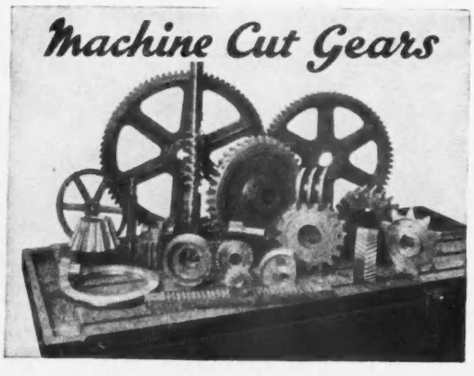

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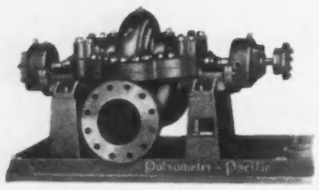

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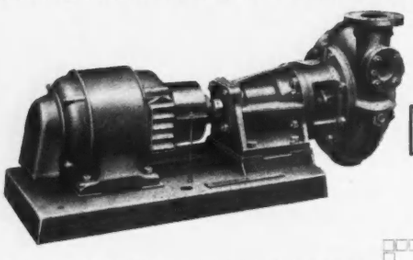

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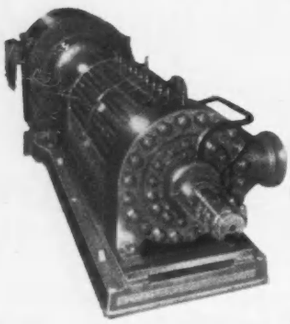

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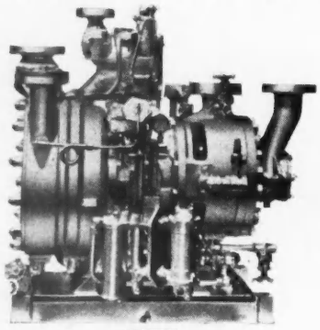

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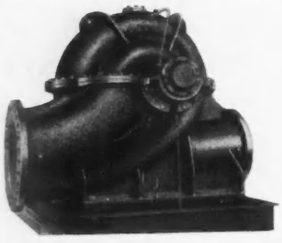

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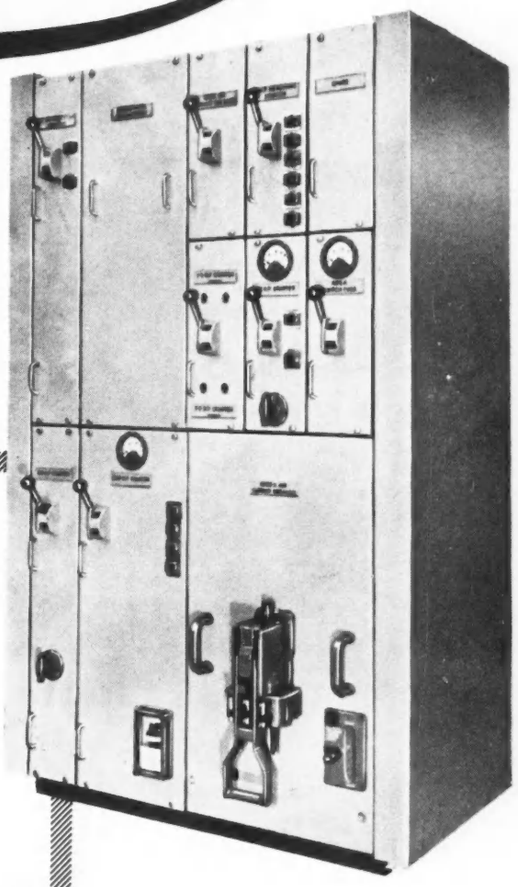

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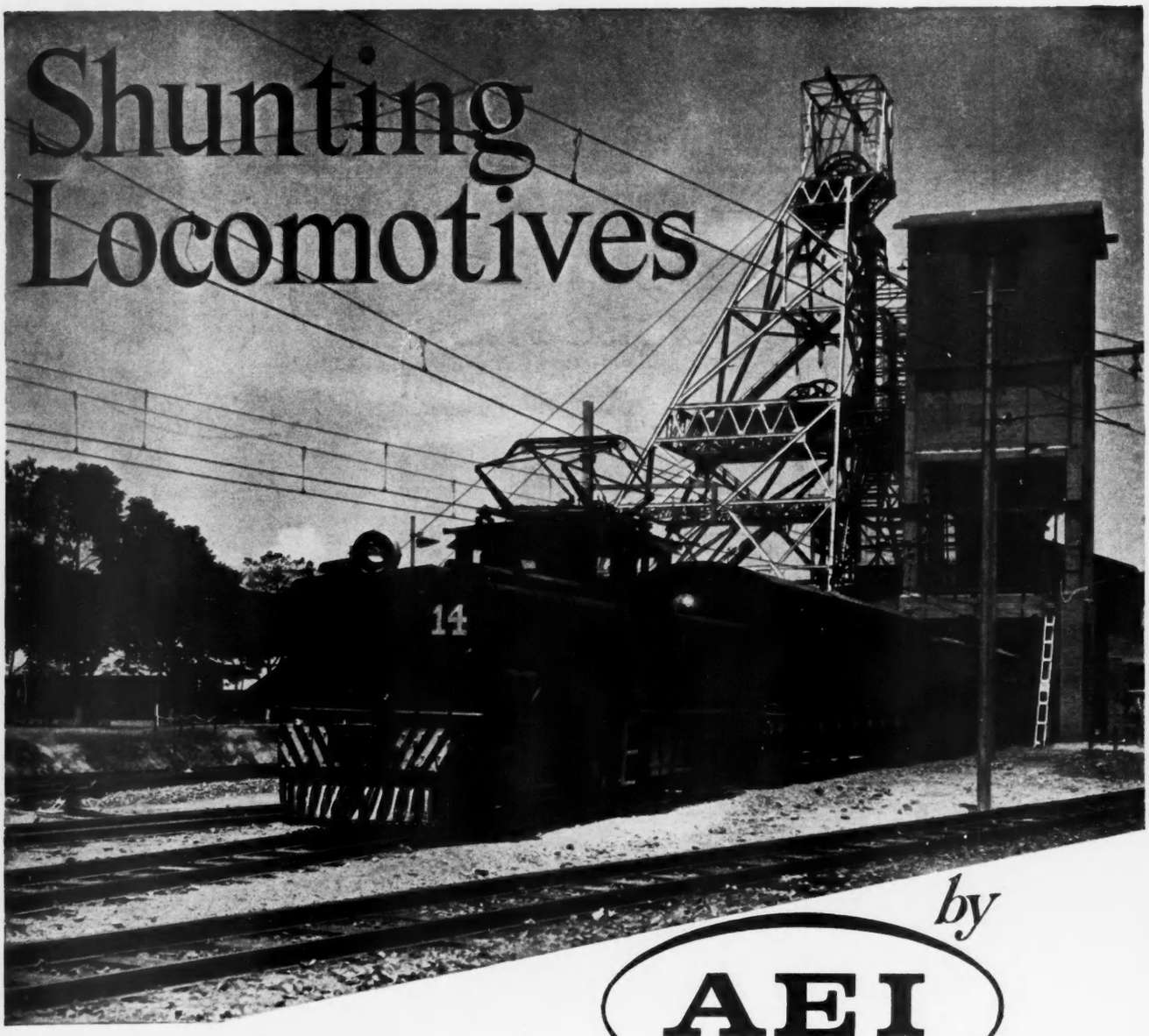

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